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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 180.
B. T. GALLOWAY, *Chief of Bureau.*

AGRICULTURAL AND BOTANICAL EXPLORATIONS IN PALESTINE.

BY

AARON AARONSOHN,

DIRECTOR OF THE JEWISH AGRICULTURAL EXPERIMENT STATION AT HAIFA, PALESTINE.

ISSUED AUGUST 4, 1910.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

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B. T. GALLOWAY, *Chief of Bureau.*

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BY

AARON AARONSOHN,
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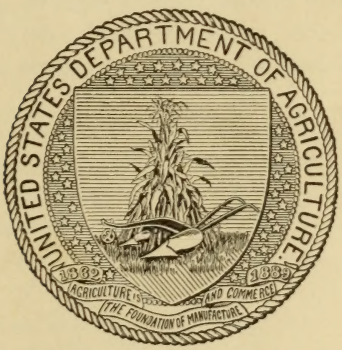

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 4, 1910.

Sir: I have the honor to transmit herewith a paper entitled "Agricultural and Botanical Explorations in Palestine," by Mr. Aaron Aaronsohn, Director of the Jewish Agricultural Experiment Station at Haifa, Palestine, and to recommend its publication as Bulletin No. 180 of the series of this Bureau.

The paper contains a summary of agricultural observations on a considerable number of economic plants indigenous in Palestine, more particularly cereals, that are considered worthy of introduction into the United States, the very close similarity of the natural conditions of Palestine to those of California and the adjacent States of the Southwest being pointed out. At the suggestion of Mr. David Fairchild, Agricultural Explorer in Charge of Foreign Seed and Plant Introduction, Mr. Aaronsohn has spent several months in the United States inspecting our agricultural industries and experiments in the interest of his work in Palestine and in studying American conditions, especially in dry-land regions. This experience has peculiarly fitted him to recognize plants adapted for introduction into America.

Mr. Aaronsohn is known in the scientific world for his botanical explorations of Palestine, and particularly for his discovery of the wild emmer, from which our cultivated types of wheat and related cereals seem to have been derived. This plant was found to cover large areas on the slopes of Mount Hermon. The study of wild ancestral forms of our cultivated plants is yielding many facts of practical assistance in the work of introducing, acclimatizing, and breeding improved varieties adapted to the endlessly varied conditions found in the United States.

Respectfully,

G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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AGRICULTURAL AND BOTANICAL EXPLORATIONS IN PALESTINE.

INTRODUCTION.

The economic and agricultural importance of the Orient is beginning to be appreciated in the United States more than anywhere else. Agricultural explorers have not only brought back important economic and ornamental plants, but have gained broader views and have seen the possibilities for a wonderful new development in agriculture. They have learned in the Orient that there is every reason to hope that the vast arid and semiarid regions of America can be rendered productive, although from the point of view of the European agronomist they would appear as worthless deserts.

Economic exploration rather than scholarly research is needed to make the countries of the Orient known and appreciated abroad and to renew a belief in the ancient saying "ex Oriente lux" (light comes from the Orient). The United States may expect its most valuable agricultural introductions from the Orient. The Smyrna fig and the Thompson Seedless grape have already been brought from the Orient, to mention only two examples of fruits. From the Orient have also come the oats of Kherson and the hard wheats of Russia and Turkey, which have made it possible to extend the cultivation of cereals to regions that were uncultivated before their introduction. But this is only the beginning. My own observations in the Orient, as well as in the Middle West and Southwest regions of the United States, lead me to believe that all that has been done in this direction is only a splendid beginning.

In fact, the Orient still remains almost unexplored and unknown as to its agricultural possibilities. In the oriental countries can be found almost all of the wild types which our prehistoric ancestors utilized in producing the cultivated crops of our time. Here, also, are to be found some of the best cultivated varieties, developed by the combined efforts of man and nature for thousands of years. New countries, especially those of the west, can here obtain the plants best adapted to their needs.

An idea of what the Orient holds for those who will take the trouble to explore it can easily be gained by considering the useful

plants which I think should be introduced from Palestine, a part of the Orient which I have made my special study.

ANALOGY BETWEEN PALESTINE AND CALIFORNIA.

Palestine is more like the State of California than any other in the Union in everything except size. It lies between longitude 34° 30′ and 36° 30′ east, and between latitude 30° 30′ and 33° 45′ north. It is practically a California reduced to about one-twentieth in size, but markedly similar in general topography, climate, vegetation, and agricultural and economic possibilities.

GENERAL CONFORMATION OF PALESTINE.

Like California, Palestine (see fig. 1) is longest from north to south. Like California, too, it has both very high mountains, having an elevation of 9,000 to 10,000 feet, and very deep depressions. The Dead Sea, 1,200 feet below sea level, is the greatest depression known, and, like the Death Valley of California, it is situated in the southern extremity of the country.

Such formations always give rise to a great diversity of soil and vegetation. Where a very ancient civilization exists, as in Palestine, such formations likewise favor the development of many varieties of cultivated plants and give rise to different methods of cultivation.

Passing from west to east, we have in Palestine (see fig. 2) the coast zone, extending along the Mediterranean, similar to the littoral region of the Pacific, and the zone of hills and plateaus of the mountains of Judea and Galilee, forming, so to speak, the backbone of the country and being similar to the foothill region of California. Farther east we have the valley of the Jordan, the diversified parts of which are similar in soil, climate, and agricultural possibilities to the San Joaquin, Imperial, and Death valleys. Finally, still farther east are the plateaus of the Trans-Jordan, with their fertile soils of volcanic origin, devoted from time immemorial to pastures and the cultivation of cereals. They are regarded as the granary of the country and have been famed since Bible times for the abundant herds of Bashan. Extending eastward these plateaus pass into the steppes and, finally, toward the south, form the deserts of Syria and Egypt.

CLIMATE AND RAINFALL OF PALESTINE.

In Palestine, just as in California, we have a dry, warm season and a humid and more temperate one. The rainy season extends from October to May, and the dry season from May to October. The rainfall varies, according to the locality, from less than 6 inches in the extreme south near the Egyptian frontier, where rains are insufficient and uncertain, to more than 40 inches in the north of the country.

Palestine is even more favored than California with regard to the winter temperature. Although the thermometer rises as high in summer in Palestine as in California, with extremes of 110° to 115° F., though not so often, it very rarely drops in the winter to the freezing

FIG. 1.—Relief map of Palestine, showing the coast region, the Jordan Valley, and the unexplored regions of the east.

point. Snow is rare, even on the plateaus, and our farmers are practically safe from any damage by frost over nearly the entire extent of the country.

GEOLOGICAL FORMATIONS OF PALESTINE.

Geologically the Paleozoic age in Palestine is represented in the extreme southeast by granite and gneiss; the Secondary formations

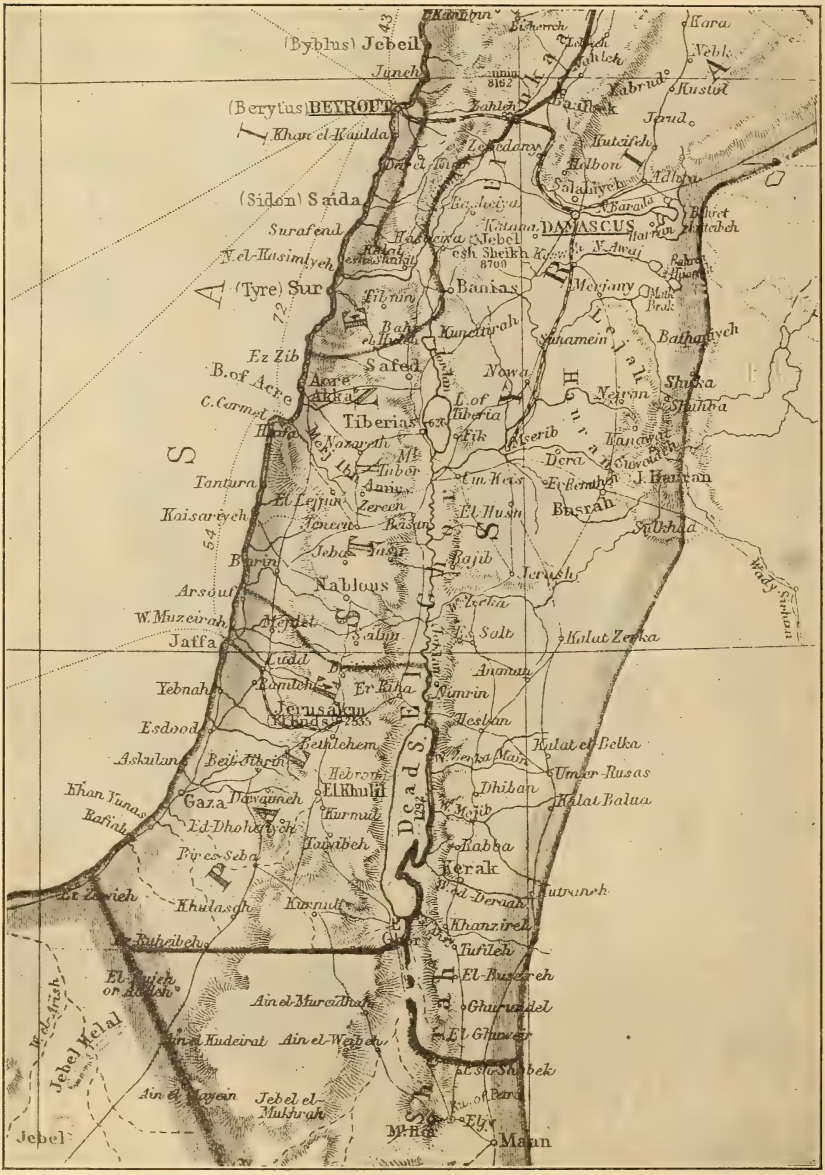

FIG. 2.—Map of Palestine, showing the location of the principal towns and villages.

appear in the extreme northeast in the Jurassic, and the Cretaceous is found everywhere in the form of sandstone, hard limestone, and

dolomite belonging to the Cenomanian and Turonian ages and soft limestones and beds of flint being generally attributed to the Senonian age. Finally, my own discoveries have shown that the lower Eocene of the Tertiary age, which was unrecognized for a long time, covers a vast area here. This formation is abundant in the south, where erosion has reduced it to thin layers, and in the north, where it is characterized by nummulitic limestone. Finally, there are the Pliocene and the Pleistocene, the alluvial, diluvial (see Pl. I, fig. 1), and volcanic deposits, which in the form of basalt and basaltite are found over vast stretches of territory in Samaria and lower and upper Galilee, and especially in the Trans-Jordan. The Trans-Jordan is very similar to the vast volcanic region of California and Oregon, and to that of Idaho in the neighborhood of Pocatello and in other localities in that State.

Because of its diversified geologic formations the country presents a great variety of soils, but fortunately the calcareous element predominates, for it is this element which is of the greatest importance in the soils of arid and semiarid regions, being second in importance to water only, which is indispensable for maintaining animal and vegetable life.

As is to be expected from this great variety of soil and climate, the vegetation of Palestine is remarkably rich in species and presents types of both desert and alpine floras.

VEGETATION OF PALESTINE.

Curiously enough, the list of the flora of the small territory of Palestine includes approximately the same number of species as that of California—about 3,000. This is nearly twice as many as are known in Algeria, which has the same variations of soil and climate as Palestine but is about fifteen times as large.

There are many other points of similarity between the vegetation of California and that of Palestine. In both sections evergreen shrubs predominate. The same forms of vegetation, often the same genera, are found on Mount Tamalpais, California, and on Mount Carmel, Palestine; the maqui formation of Palestine is to be compared to the chaparral and chamiso of California, and the forms of vegetation of the Lebanon and the Hermon mountains are much the same as those of the western slope of the Sierras.

On account of the predominance of the calcareous element in the Palestine soils already mentioned, the lime-loving leguminous plants are well represented. The genera Medicago, Melilotus, Trigonella, Astragalus, Trifolium, etc., are rich in species which aid in maintaining fertility by means of their nitrogen-fixing character. These furnish good temporary pastures in winter and spring, and during

the long, dry summers the cattle relish the hulls which cover the ground. The introduction of these remarkable leguminous plants into the Southwest, and their cultivation and selection, may be expected to contribute greatly to the improvement of the range. This analogy of the flora of Palestine with that of California justifies our expectation of the best results. The plants of Palestine are, so to speak, the homologues of those of California, and, a priori, their success seems assured.

The success of the useful xerophytes (see fig. 3) and halophytes of the Palestine deserts when introduced into the Southwest ought

FIG. 3.—Seyal acacia tree near Engedi, on the western shore of the Dead Sea. The rough flooring in the branches is used by Arabs as a summer dwelling.

to be even more certain than would that of the plants of the Southwest if transferred to Palestine, and for the reason that in the desert districts surrounding Palestine the rains come, when they come at all, only during a single short season between October and March. On the contrary, in Arizona, for example, there are two rainy seasons during the year. This would be a great advantage to the leguminous annuals and grasses introduced from Palestine.

In the territory with which we are dealing we have, as has been shown, a large number of wild species and varieties. If we consider the varied natural conditions of Palestine and the peculiar

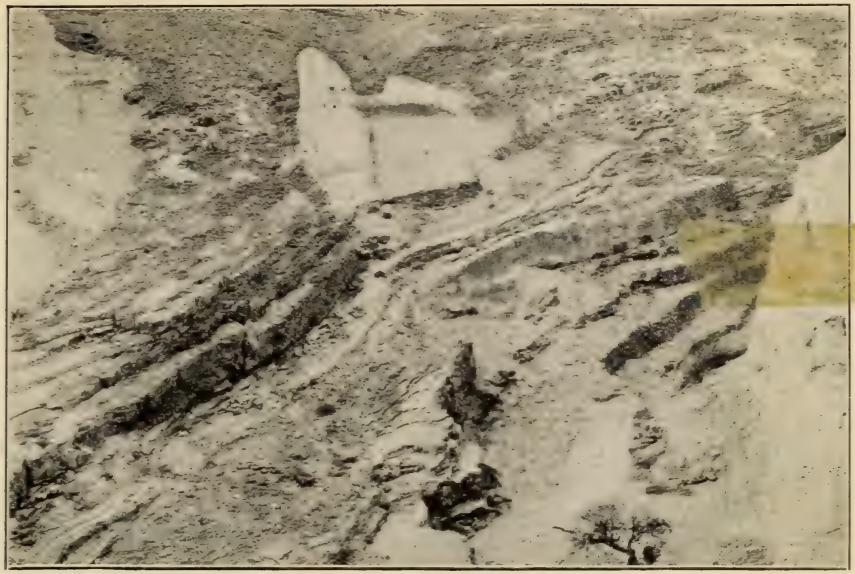

FIG. 1.—KASR-EZZUWEIRA, SHOWING THE EFFECTS OF EROSION ON THE "LISSAN" STRATA, LAYING BARE THE UNDERLYING ROCKS.

FIG. 2.—VIEW OF SAFED. ON THE LEFT IS THE ROCKY MOUNTAIN, DESTITUTE OF FOREST VEGETATION, WHERE TRITICUM DICOCCUM DICOCCOIDES WAS FOUND.

methods of cultivation which have been brought about by political conditions—the vicissitudes of war, the continual migration of tribes, and colonization—all acting through such long periods of time, we can readily understand why so many varieties of cultivated plants have been developed and why the country is such an interesting one to study and is so full of promise.

ECONOMIC PLANTS WORTHY OF INTRODUCTION INTO THE UNITED STATES.

PLANTS RECOMMENDED AS STOCKS.

Zizyphus spina-christi (*Christ-thorn*).—This tree averages 16 feet or more in height, with a diameter of 16 to 24 inches. Its fruit, about the size of a hazelnut, is not so well liked as that of the species mentioned later. It is a tree which is found along the coast and in the valley of the Jordan. There are several local races adapted to different life conditions. In the valley of the Jordan, and especially farther south in the valley of the Arabah, it is the most common tree on alkaline soils.

The Arabs water their land very abundantly and do not provide any drainage, and as a consequence great quantities of alkaline salts are brought to the surface. At the end of two or three years the soil is so excessively salty that the land is abandoned for a number of years until the rains have washed the salt down into the subsoil. *Zizyphus spina-christi* grows on these lands abandoned on account of their excessive alkalinity, so that when an explorer finds a field overgrown with this plant he can be sure that it has formerly been under cultivation.

Zizyphus spina-christi inermis.—In very moist lands along the banks of streams, for example those of the Jordan near Jericho, the type plant loses its thorns (thorny stipules or stipular spines). The resulting variety is called *inermis* (spineless).

Zizyphus lotus.—This bush rarely grows to a height of 6 feet. It tends rather to give off suckers, thus spreading continually and forming clumps of large diameter. This characteristic makes the plant very valuable for the fixation of dunes. It seems to be more particularly adapted to inland dunes, although it has been grown successfully along the coast. The fruit of this species, although smaller than that of *Z. spina-christi*, is more palatable and, under the name of "Dôm," is eaten dry by the Arabs throughout the valley of the Jordan, and also by the Jews of Tiberias. The taste is a little like that of dried apples.

Zizyphus lotus seems to be less adapted to alkaline ground than *Z. spina-christi*, but grows on the most arid hills. In the vicinity of Tiberias and farther south and east it is the only bush which

grows on the black basalts, where in summer a burning temperature prevails.

I believe that *Zizyphus spina-christi* and *Z. lotus* may be of great value as stocks for Chinese jujubes or t'saos (*Z. sativa*) and that by their use we can extend the cultivation of this fruit to regions where it is now absolutely impossible on account of excessive dryness or excessive alkalinity of the soil. These stocks seem to me to be especially adapted to the Imperial Valley of California.

Paliurus spina-christi.—Another species related to the two already mentioned is *Paliurus spina-christi.* This is a bush 10 to 13 feet high. It does not extend so far south as the two preceding species, but thrives on the plateaus of upper Galilee, where it is used for hedges around unirrigated olive plantations, and also at the foot of Mount Hermon, where hedges of it are planted around irrigated fields.

This species, also, should be tried as a stock for the Chinese jujube. It is adapted to less arid soils than *Zizyphus lotus* and does well on those having a considerable degree of moisture and in regions where the winters are relatively severe.

If these three species, *Zizyphus spina-christi*, *Z. lotus*, and *Paliurus spina-christi*, graft readily with the Chinese jujube, we shall have stocks for this fruit available for all kinds of soil—moist, arid, and alkaline—and for both high and low altitudes—from 3,300 to 4,000 feet above to 1,300 feet below sea level.

Pistacia terebinthus and Pistacia palaestina.—These species will furnish stocks for *Pistacia vera*, the true pistache nut, a crop which can be made of great value in the United States but which has not as yet been much cultivated here. Each of these species is 13 to 26 feet high and 2½ feet or more in diameter. They are found in all sorts of soil, particularly in crevices of calcareous rocks. *P. palaestina* is found more frequently than *P. terebinthus*, which seems to prefer moister soils. The former grows in the valley of the Jordan and extends as far as Petra and the Arabah, generally in slightly moist sandstone soils. This plant is especially to be recommended for the vicinity of Indio and Mecca, Cal.

Pistacia atlantica.—This variety has proved to be a good stock for *Pistacia vera* (the pistache), and I believe that *P. terebinthus* and *P. palaestina* will also prove valuable and should be imported and tried in the United States. The male flowers of *P. terebinthus* are often used in Asia Minor for the pollination of *P. vera*, and it may be that in this way we can increase the productiveness of *P. vera* in the United States, where hitherto it has not yielded well.

Amygdalus communis.—The wild almond is very common in Palestine and Syria; that is, a really wild almond, not one that has escaped from cultivation. It covers a very extensive area, and there-

fore a number of varieties and local races have developed. These merit careful study. Some are found in the cretaceous and nummultic rocks of Samaria; others prefer the basaltic hills of Gaulanitis, etc. These wild almonds are plentiful enough to furnish an article of commerce. The Bedouin women of Gaulanitis (Djôlan) gather the bitter almonds and carry them to the market at Damascus. We get wild almonds from the region of Nablus (the ancient Shechem) from which to grow stocks for our nurseries. They are excellent stocks for almonds and for apricots on dry and nonirrigable lands.

Amygdalus orientalis.—I believe that this species is also worthy of being recommended, although I must admit that I have had no personal experience with it. It is common on Mount Hermon, and I know it to be one of our hardiest species. It thrives in crevices of rocks looking toward the east, thus being exposed to the hot, dry winds of the desert. It extends to altitudes of 3,300 to 5,000 feet and is very resistant to the rigorous winters of these high regions. It is therefore one of the best species to test as a stock for poor soil in barren regions. It should prove valuable in Washington, Oregon, and Colorado.

Prunus microcarpa and Prunus ursina.—All that has been said about *Amygdalus orientalis* applies also to *P. microcarpa* and *P. ursina*, which appear in the same localities and under the same conditions. The fruits of *Prunus microcarpa* are slightly bitter but very refreshing, and the writer has often enjoyed them when tired out from long walks in this region. The seed has a thin shell which is easily broken.

Prunus ursina (bear plum) has a globular fruit, violet-red or yellow when ripe, an inch in diameter. It takes its name from the fact that bears, said to be formerly numerous on Mount Hermon, but now exceedingly scarce, are very fond of it. It is also eaten by the shepherds and by the wives of the peasants. It is a bush 6 to 10 feet in height, with a trunk 4 inches to 1 foot in diameter.

Prunus cerasia.—This shrub is very interesting on account of its fruit, which is quite similar to the damson in taste and appearance. The seed, however, is longer and more pointed. The fruit is oval and one-half inch to 1 inch in length. This shrub is cultivated more for stock than for its fruit, which is astringent and not very agreeable. It is possibly the prototype of the cultivated damson. This seems the more probable from the fact that the word "damson" is thought to have been derived from Damascus.

Crataegus.—Among other species of Crataegus the most important is *Crataegus azarolus* with its numerous varieties and races. This is a shrub of the calcareous hills and appears only on very dry lands. If undisturbed it grows as high as 13 to 16 feet, but its branches are generally hacked off for fuel by Arab women or

mutilated by heavy stones thrown by the boys to shake down the fruit. Some varieties of *azarolus* have fruit as large as a large cherry, with a very agreeable acid taste. Although they are sold on the markets of the Orient, they would not be marketable in Europe or America because of the large stones, as in the case of the loquat (*Eriobotrya japonica*); but specimens are often found which are nearly stoneless, and it is possible that this character could be fixed by selection.

For fifteen years or more the writer has used *Crataegus azarolus* as a stock for pears with excellent results. Top-grafted at 2 to 3 feet above the ground, it develops into very beautiful, productive, and long-lived dwarf trees, provided the grafting is done with very early varieties. This shrub occurs in extremely hot, dry places and must therefore complete the greater part of its development early in the season. Its roots, therefore, are unable to furnish the amount of sap necessary to develop pears in August. If, however, it is grafted with a pear which fruits in May or June, when the roots of the Crataegus are in their period of greatest activity, the best results are obtained. I have found this to be true in Palestine, and Mr. Dumont, near Tunis, who has grafted hundreds of wild Crataegus plants, also finds that he is successful only with early varieties of pears.

I may also mention *Crataegus orientalis*, having a large and palatable fruit, and *Crataegus sinaica*. Although the fruit of this species is scarcely larger than a pea, with a dry and tasteless flesh, it will grow on the very driest lands. All of these species of Crataegus are spiny. They are par excellence the stocks for pears on dry lands and calcareous ridges. The writer speaks only of pears, because he has experimented with them, but he sees no reason a priori why these stocks should not do as well for apples, which he has not as yet tried.

Pyrus syriaca.—This wild pear ought to be considered along with the species of Crataegus. It would be adapted to an even greater range of soil, for, though the Crataegus species appear only on very porous soils, some races of these wild pears grow in very humid localities, almost swampy, or at least submerged for two or three months of the year. *Pyrus syriaca* is a shrub 13 to 20 feet high. The branches of young plants and the suckers at the base of the trunks of old trees are very spiny, but there are no thorns at the top. The fruit is a favorite with the peasants and shepherds. It grows, as said, on damp soils at sea level; it is also found in the forests and underbrush on hills and plateaus. Sometimes a single tree stands by itself without any protection from the winds and the burning sun. It grows at 2,500 to 3,000 feet altitude on the Senonian chalks, as well as on the dolomitic and nummulitic limestones of

upper Galilee and also at 3,300 feet and more on the Jurassic beds and the lower Cenomanian sandstones of the slopes of Mount Hermon. It seems to the writer to be a very promising stock. It was in this region that Kotschy found some wild pears, which were so good in flavor that he named them *Pyrus nobilis*.

FRUITS.

In addition to the wild types which are excellent for stock and may yield some valuable results by hybridization and selection, we may note some of our cultivated fruit varieties which would be worth trying in the United States.

APRICOTS.

The almond is generally used as stock for the apricot, except in irrigated orchards such as those in the region of Damascus, where the varieties desired are grafted on "Muschmusch kelabi" (dog apricot, or bitter-seeded apricot). *Prunus spinosa* is rarely used as stock, and then only in northern Syria.

Syria and Palestine have a great number of varieties of the apricot. I have secured from Damascus alone eight varieties for my own use. There is a difference of fully two months between the ripening of the earliest and of the latest varieties in this one place under the same conditions of cultivation. These varieties differ in habit of growth, productivity, appearance, and taste of fruit. Only one variety, "Muschmusch kelabi," has bitter kernels; the kernels of all of the others are sweet and are eaten like almonds. The annual export of "kelabi" kernels from Damascus alone averages 60,000 pounds. Some varieties have especially good shipping qualities. They are packed, without being wrapped, in boxes that have been used for the importation of Russian petroleum. They are carried upon mules, sometimes for two or three days, over precipitous, rocky paths, and yet, in spite of all this and of their being exposed to great variations of temperature, they reach the markets in excellent condition.

Other apricots, like the "Tadmuri" (meaning Palmyrian), though splendid fruits, are not very productive and would not stand the conditions just described.

The "kelabi" is used only for the manufacture of apricot paste. Spread in a thin layer and dried in the sun, it looks like a piece of leather. It is treated with a little oil, so as to prevent its becoming brittle. It can then be rolled up, and, being very easy to carry, it forms an important part of the rations of the Mohammedan soldier. On account of its value to him in his religious campaigns it is called "Kamr-ed-din" (the crescent). This paste is an important

article of commerce, and I shall later write a special article on its preparation and uses. Here I wish only to say that, at my suggestion, some experiments in its manufacture were made during the present year in the Santa Clara Valley, California, and with a gratifying degree of success. It is therefore not impossible that the utilization of "slab" apricots in making this paste may prove of importance, especially during years when there is a large percentage of low-grade fruit. This may result in the establishment of a new industry for the utilization of apricots, the product being shipped to the mining districts.

QUINCES.

The quince is cultivated in different regions and under various conditions of soil and climate. We have some varieties adapted to irrigated orchards only; others that yield fruit on the cool, but dry, plateaus of Samaria. Some varieties have fruit edible when ripe; others are always astringent. All yield a beautiful ruby-colored jelly of a very fine flavor.

POMEGRANATES.

Pomegranates are extensively cultivated in Syria and Palestine, although the crop is not one of great commercial importance. They grow in wild thickets, having escaped from cultivation, and are very drought resistant. Pomegranates are also cultivated in almost all orchards, both with and without irrigation. They comprise two groups, the acid fruited and the sweet fruited. The latter includes those fruits with large, hard seeds and the form called "Malissi," or seedless. As a matter of fact they have seeds, but these are small and thin shelled. There are a great number of races among the "Malissi." The "Bint-el-Bascha" (daughter of the pascha) grows at Gaza, in southern Palestine, at sea level. This name is given by the Arabs to different fruits or products of special excellence. These varieties are found on deep, Quaternary soil and they require irrigation. They have been famous from ancient times and are exported to Egypt and other lands. Er-Reineh, a christian village in lower Galilee, between Nazareth and Tiberias, is also known as Um-er-Ruman (mother of the pomegranate), because so many varieties of such excellent quality are produced there. They grow at 1,000 to 1,300 feet altitude in calcareous soils. The pomegranates of Jericho and the oases are much liked. They grow readily in very alkaline soils.

OLIVES.

We now come to two characteristically oriental crops, grown there for centuries and always of great importance, viz, the olive and the fig.

In spite of all that has been said and written about the Oleastrum, the Zeboudj of the Kabyles (Algeria), the writer believes that it is only an olive escaped from cultivation. The wild olive certainly originated in the hills and mountains of Syria and Palestine, rather than in those of Algeria. At any rate, there are different varieties or races of wild or half-wild olives in our hills adapted to all kinds of soil and to widely different climatic conditions. Though they would not be ranked botanically as varieties, there are three distinct races among our wild olives which are used either for direct planting or in our nurseries.

The first is a form with thin, brittle, blackish bark. This form is not much liked; it is difficult to propagate, grows slowly, is hard to graft, and the fruit produced by these grafts is said to be not very rich in oil.

Second, there is a form with waxy green bark. This is easily propagated, grafts readily, is very much liked, and when used as a stock gives a very large yield of oil, but it is of rather slow growth and it fruits late.

The third form has a thick, white or gray bark, which separates readily. It is particularly well adapted for grafting, is easily propagated, grows rapidly, and fruits early. It is said that the trees of this race do not live as long as those of the preceding one.

All of this information is not guaranteed, as some of it was obtained from the Arabs, but that part which relates to propagation, growth, and grafting is from personal observation.

There is, as is to be expected, a great multiplicity of forms in the cultivated varieties of olives (see fig. 4). In southern Palestine we have olives which grow under much the same conditions as the Chemlali of Sfax (Tunis), the soil and climate being about the same and the rainfall as limited. I may note, however, that the varieties from Gaza, Ramleh, or Lydda, which grow in southern Palestine on Quaternary soil, do not contain the excess of margaric acid which is characteristic of those from Sfax. This is a great defect in those varieties and is the cause of their oil being rated as inferior. To be sure, the oil of southern Palestine is also rancid and mediocre in quality when prepared in the Arab fashion, but excellent when well prepared.

Just as the name "Chemlali" is applied in Algeria and Tunis to several different forms, so also in Palestine the name "Nabali" has a somewhat indefinite use. The Nabali of Et-Tireh, near Haifa, growing on calcareous Cenomono-Turonian formation, and the Nabali of southern Palestine, growing on Quaternary soil, are altogether different. The first is richer in oil and is of superior quality. One form in this locality is particularly in demand because it is more productive and yields more oil, and that also of a finer quality. But we are not

sure that this difference is really one of variety; the superiority is probably due to the soil. The villages of Et-Tireh, Ijzim, and Ain Ghazal (mother of gazelles), in the foothills of Mount Carmel, are renowned for this superior olive. All the trees reported from there were found to grow in rich land made up of volcanic tufa and disintegrated basalts from the old eruptions of the Secondary epoch.

Er-Rameh, in upper Galilee, 1,300 to 2,000 feet in altitude, holds the record for the productivity and quality of its olives. There is here a fair degree of uniformity in the character of the fruit, and the best methods of cultivation in the country are here in use.

A number of other varieties are found in the region of Damascus. The altitude here is 2,000 to 2,300 feet, and the winters are rather

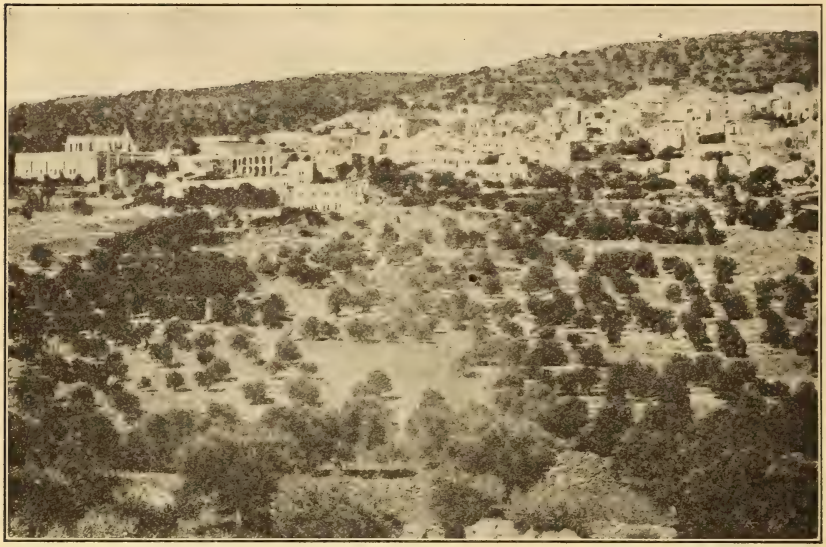

FIG. 4.—Olive groves on rocky soil in the environs of Jerusalem, showing artificial terracing.

severe. Some of these varieties are especially rich in oil; others particularly well adapted for table use. The only one called "Damascus" olive remains green in color until ripe and is preserved simply by means of lye made of ashes. It is often as large as a pigeon's egg, larger than any of the Spanish "aceitunas Sevillanas" or "aceitunas de la Reina" that I have ever seen.

As the winters are mild in the particular regions where I have carried on my work, I have studied the resistance of our forms and varieties in relation to heat and drought rather than to cold. But as there are varieties growing in parts of Palestine where the winters are severe I have no reason to doubt that there are forms among these which will grow well in those parts of California, Texas, etc., where winter temperatures are relatively low. In fact, our olives extend

through a vertical range of nearly 6,500 feet. They grow under irrigation at Abedieh and Jericho, in the valley of the Jordan, at 650 to 850 feet below sea level. They are commonly cultivated at Hermon and at Lebanon, 4,000 to 5,000 feet in altitude, where the winters are long and relatively severe. In upper Galilee—in the region of Safed, for instance—at an altitude of 2,000 to 2,500 feet, it is claimed that low winter temperatures increase the olive crop; for it is stated that whenever the winters are cold (that is, the temperature reaches 14° to 18° F.) the crop is always abundant. If this generally accepted opinion is true the increased production is to be attributed, according to my opinion, not to any beneficial effects of cold upon the tree but to the fact that such low temperatures probably kill most of the parasites, particularly the olive scale (*Lecanium oleae*). This is very prevalent and the people know no way of combating it.

FIGS.

Though the fig is not cultivated to so great an extent in Palestine as in Smyrna, it is, nevertheless, a very important crop, particularly in upper Galilee, where the population is very dense and labor is cheap. There are a great number of varieties there—some with black fruit, others with green, and still others with pink. Some of these figs can be used only while fresh. These are not very extensively cultivated, there being practically no shipping facilities. Other varieties are dried and pressed and, to some extent, shipped abroad. They are, however, chiefly consumed by the Bedouins, whose liking for "kutteins" (dried figs) is proverbial. These people are not at all critical, so that no effort has been made to improve the methods of preparing this product or to study the best varieties for cultivation.

It is our wild figs, however, rather than our cultivated varieties, that will probably prove of the greatest value in the United States.

Ficus carica.—This species and its numerous varieties grow wild abundantly in the crevices of rocks. The openings of the numerous mountain caves are generally shaded by these wild trees. In the valley of the Jordan, in the neighborhood of Fusail, there are patches of humid soil, of a black color generally, characteristic of the injurious carbonates. The wild figs nevertheless grow there, showing that they are particularly resistant to alkali. This fact should make them a valuable stock in California. The Smyrna fig has been established in California, but this variety does not show a great degree of resistance to alkali. I firmly believe that the local races growing in Palestine on alkaline soils will be of great value as stocks to the fig growers of California. I say "races" rather than "varieties" because the use of this latter word has been so much abused by some authors.

Ficus pseudo-sycomorus.—This species is not very abundant. It grows on the edges of cliffs and at the entrances of caverns in the desert, and it is especially resistant to drought and alkali. I do not know that it has ever been tried as a stock, but I do not hesitate to recommend it for introduction and experiment.

Ficus sycomorus.—This tree (see figs. 5 and 6) deserves our attention. It is a native of India and grows all along the Palestine coast as far north as Beirut. It is very drought resistant, and in southern Palestine grows to a considerable size. Its wood is highly valued on account of its great density and the size of the trunks. It is used particularly to make sledges for thashing. But it is the use of the fruit as forage which should make it of value for certain parts of the United States. Although it is of inferior quality, it is greedily eaten by the Bedouins. The tree yields very abundantly, the fruit covering all of the old branches and even the trunk. It has several successive flowering periods, and the Arabs say that the "Djemeiz" gives seven harvests a year. The quantity of fruit yielded by a single tree is simply incredible, and the fruit, which is tolerably rich in sugar, would be in arid regions an excellent food supply for sheep and hogs. The tree grows well on dunes.

FIG. 5.—Fig tree (*Ficus sycomorus*) near Jaffa, showing its unusual resistance to drought. The roots are laid bare by the wind, and the branches on the windward side are checked in development by constant and strong sea breezes.

DATES.

At the present time date cultivation in Palestine is not of any great economic importance. But this has not always been the case. In biblical times Jericho, in the valley of the Jordan, about 600 to 700 feet below the level of the sea, was called the "City of Dates." At the beginning of the Christian era, when Tiberias and its environs were the Riviera of that time and when the princes and princesses of the Orient went there to spend the winters, the city of Magdala was celebrated, not only for its establishments for cleaning and dyeing the valuable costumes of its noble visitors, but still more for the delicious early dates which it produced.

To-day the cultivation of the date in the valley of the Jordan is of no importance whatever. Only the village of Abadieh still has a

few date trees of a local variety, the fruit of which is of good quality. But the people who are establishing new plantations, instead of propagating this local variety, prefer to send to Egypt or Bagdad and bring from a distance and at great expense plants which are really of less value than the local product.

There are two places, however, where the old date plantations have not entirely died out. The first is east of the Dead Sea in the Valley of Zerka Maain, the ancient Calirrhoe, once celebrated for its hot baths, frequented by King Herod. Here thousands of date trees grow wild in crevices of arid sandstone 600 to 800 feet below sea level, in narrow gorges intensely hot and dry, where the soil is extremely alkaline.

The second place is farther north, in the valley of the ancient Hieromax, 500 to 600 feet below sea level, in a marsh formed by several hot springs, with a temperature of 118° to 133° F. Here these wild dates form a veritable jungle, probably one of the few places of its kind in the world.

FIG. 6.—Fruit of fig tree (*Ficus sycomorus*). The Arabs in Biskra and Egypt cut off the tips of the immature figs in order to make them ripen. Three days after this is done the cut figs become twice as large as those uncut and develop a much better taste. The fruits marked "*I*" have been cut.

The historical accounts which vouch for the quality of the dates produced in these regions furnish proof that the cultivation of this fruit can be made profitable in such localities, and we may reasonably expect that the variety found in and around the valley of the Jordan may be of value for certain similar localities in the San Joaquin Valley.

Along the coast of Palestine, in sandy soils and on the edges of dunes, the date is here and there cultivated, especially in irrigated orchards and gardens. The ordinary varieties, however, do not ripen without artificial aid, and to this end the Arabs wrap the bunches of fruit in cloths soaked in vinegar. These cloths are kept constantly

moist. When the wrapping of the fruit is discontinued the dates have changed from a black or chocolate color to an amber-yellow and have lost their astringent taste, the tannin having probably been rendered insoluble by the acetic vapor.[a]

It is probable, as suggested by Mr. Fairchild and Mr. Swingle, that the Japanese method of artificially ripening persimmons by putting them in barrels that have contained "saki" is based on this same principle, and that the astringency of the fruit is overcome in this case also by acetic vapor.

GRAPES.

Though the religion of the Mohammedans forbids the use of wine, they cultivate grapes extensively and have developed a great number

FIG. 7.—Commercial grape nursery at Hedera. The workmen, Russian and Koordistan Jews, can understand each other only in the Hebrew language.

of varieties. (See fig. 7.) Before the German and Jewish colonization began in Palestine, grapes were cultivated chiefly for table use and for raisins.

For the most part the Mohammedans have propagated varieties that are not very juicy, having hard flesh and strong skins, as the

[a] When I visited Tucson, Ariz., on September 27, 1909, I had the pleasure of explaining this process to Doctor Vinson, of the University of Arizona. He began immediately to experiment along this line, and I am very much gratified with the success secured by him. See report of his experiments in Science, n. s., vol. 30, no. 774, pp. 604–605. I believe that this process of artificial ripening ought to be experimented with in other States where, as in Arizona, there is difficulty in getting certain varieties of dates to ripen.

fruit often has to be carried for days on the backs of donkeys or camels before it reaches its nomadic consumers or the people of far-distant villages. Our varieties are therefore rather distinguished for size, richness in sugar (habitually more than 18° Bé.), and good shipping qualities than for fineness of flavor. The grapes not eaten fresh are made into raisins, and the vicinity of Hebron, near Jerusalem, and more particularly of Es-Salt, in the Trans-Jordan, are the great centers of raisin production, producing about a hundred thousand dollars' worth every year. These places are at an altitude of more than 2,500 feet, and the grapes are grown on calcareous hillsides of Cenomanian and Senonian formation.

A study of the vineyards of Palestine would no doubt reveal many varieties that would be valuable to the United States. Mr. George C. Husmann, Pomologist in Charge of Viticultural Investigations, Bureau of Plant Industry, says that among the hundreds of table varieties with which he has been experimenting for years he considers the Palestinian "Dattier de Beirut" the best white grape and the "Purple Damascus" one of the best black varieties. And yet neither of these is among our finest Palestine sorts.

FIG. 8.—Seedling orange trees at Hedera, grown with a view to originating new varieties.

JAFFA ORANGES.

All of the crops mentioned have been cultivated for centuries in the Orient, but oranges were introduced there at a relatively recent date. (See fig. 8.) Hasselquist, a pupil of Linnæus, who was the first naturalist to study Palestine, in the middle of the eighteenth century, speaks of the beautiful gardens of figs and pomegranates at Jaffa, but has not a word to say about oranges. This silence is significant. But at the time of Napoleon's Egyptian campaign, at the close of the eighteenth century, the orange was mentioned among the fruit trees. Chateaubriand, who traveled in the beginning of the nineteenth century, also speaks of this fruit. Lamartine, visiting Palestine in

October, 1832, praises the beauty and quality of the Jaffa orange, but speaks of having seen the flowers and the golden fruits at the time of his visit. Now, at this season of the year it was too late for the trees to have been in bloom and not late enough for the fruits to be ripe. This and other errors of observation cause me to doubt the value of the poet's description from the point of view of the naturalist and agriculturist, although its value as literature is unquestioned.

At any rate, in the second half of the nineteenth century the Jaffa orange was known in the markets for its superior quality. It was exported by sailing vessels all along the Syrian and Egyptian coasts. Its thick skin made it a good shipper, and it was carried as far as Constantinople and into Greece. It was not until 1875 or thereabouts that it was exported to England, while to-day Liverpool alone takes about 500,000 to 600,000 cases of the 700,000 or 800,000 that are annually exported.

I have not been able to learn the origin of this variety, which is cultivated only at Jaffa. In form it is very similar to the Malta orange, and it is possible that it is remotely descended from that variety; but it is not a blood orange, despite its marked affinity to that group.

The Jaffa orange is one of the largest, larger even than the Washington Navel. Its form is obovate, its skin very thick, and its fruit seedless. The tree is not spiny, and the fruit, therefore, is never scarred. Its shipping qualities are excellent. It is packed with very little care as compared with the methods used in California. The cases are thrown violently into the steamers, and they are often carried for three weeks without refrigeration and subjected to the greatest extremes of temperature; and yet the oranges reach the English markets in good condition and command good prices. It is at least a month from the time they are picked until they are purchased by the wholesale dealer, and during all of that time they are without cold storage.

Not only is this orange peculiar to Jaffa, but peculiar methods of cultivation and peculiar stocks are there in use.[a] The Schamouti, as the Jaffa orange is called, is generally grafted on a special sweet lime, which I have not found either in Africa (Algeria and Tunis) or in the United States. It is sometimes, though more rarely, grafted on the bitter orange (*Citrus aurantium*). This is not so well liked, because it requires more irrigation and is later in fruiting.

I must add that the Jaffa oranges which I saw in Tunis and Algeria and those grown in America and illustrated in American publications

[a] See Aaronsohn and Soskin, Die Orangengärten von Jaffa, Der Tropenpflanzer, Berlin, 1902.

have very little resemblance to the real Jaffa orange. They are represented as having seeds, while the true Jaffa orange is seedless.

Saida, the ancient Sidon, is another center of orange production. Many different stocks are used, and several varieties of oranges are known. Two of these are blood oranges, one called "Damaoui" (blood) and the other "Hutmali" (meaning "ringed," because it has a ring around the base). These two varieties are very popular. The "Beledi" (seedling) is also grown. This commonly yields three thousand fruits to the tree, and sometimes as many as five thousand.

FORAGE PLANTS.

Stocks and fruit trees are not the only interesting things in the Palestine flora. It contains some very valuable forage plants. This may seem to be strange in a country which suffers from a lack of forage, but this is due to the fact that the people do not cultivate the plants they have at hand.

The Leguminosæ must be considered first. In this family we find one of the most valuable forage plants in existence for semiarid regions, the importance of which for this purpose has not been sufficiently appreciated. This is the carob tree, sweet-pod, or St. John's bread (*Ceratonia siliqua*).

The carob tree is not, properly speaking, a native of arid, desert regions. It grows 20 to 25 feet in height, with a trunk as much as 40 inches in diameter. A tree 25 to 30 years old yields about 450 to 550 pounds of pods. I have seen wild stock, 15 or 18 years after grafting, that yielded 900 to 1,100 pounds of pods in good years, although a good average is 450 pounds to the tree. Counting twenty trees to the acre, this gives more than 8,000 pounds of pods to the acre. The pods contain 40 per cent of sugar—even more in good varieties—and 7 to 8 per cent of protein, so one can readily see why we rank it at the head of all forage plants.

An acre of carob trees upon arid soil yields a much greater quantity of food matter than an equal area planted with the best alfalfa. The food value of the carob has been known for a long time. It is the basis of the fodder of the English cavalry horses at Malta and of the horses belonging to the tramway company of Naples. It is among the chief exports from the island of Cyprus, and the growing of carob trees is one of the best sources of income on the island, for, once started, the tree continues to yield for many years. In this respect it is similar to the olive, which grows in the same localities, but it is generally admitted that the carob can not stand so arid a soil as the olive, as it requires more moisture in the subsoil. However, on this point also there are differences between the local races, there being some which will stand a considerable degree of aridity. There are several wild

carob races and a few cultivated ones that should be tested by the Bureau of Plant Industry.

There are few crops so well adapted as the carob to agricultural conditions in certain parts of the United States. The tree demands little care, requires almost no pruning, does not need to be cultivated frequently, and has not so far shown any disease demanding treatment. It seems to me to be the ideal forage plant, as it gives a high yield with very little labor. It should succeed in California and in parts of Arizona and Texas.

There are many of our Leguminosæ that should prove very interesting. We shall probably learn to value many species found among the Galegeæ and Loteæ, and in the genera Vicia, Hedysarum, and Trifolium. For the sake of brevity I shall mention only one species.

There are good reasons for believing that berseem (*Trifolium alexandrinum*) originated in Palestine, though we do not know definitely where it was first cultivated. But it grows wild there, as does also *Trifolium carmeli*, which differs from it only in slight botanical characters. Moreover, *Trifolium panormitanum* and *Trifolium supinum*, very closely related to *T. alexandrinum*, grow wild in Palestine. The fact that this whole group of closely related species grows wild in this region seems to indicate that they originated here. At any rate, the cultural value of these species needs to be studied.

Though berseem is a very valuable local plant, it is little cultivated by the natives, being grown chiefly by German and Jewish colonists. It is sown with barley in the autumn along the coast, where the rainfall is as low as 14 to 16 inches per annum. It is of course grown without irrigation and gives two cuttings in the spring. In some very rainy years berseem yields three cuttings, or at least a good aftermath following the second cutting. After being pastured, the berseem is plowed under and forms an excellent green manure for a succeeding cereal crop. Egyptian berseem, grown under the same conditions of soil and climate, was found to be not nearly so good as our native races, and the latter should be carefully studied with a view to introduction.

I wish also to mention the Palestine saltbushes for alkaline soils, particularly *Atriplex palestina* and *A. halimus*, as well as *A. leucoclada*. The last grows from 3 to 6 feet high, but is so eagerly browsed by sheep and camels that it is difficult to secure even good herbarium specimens.

ANNUAL CROPS.

The greater the number of crops a farmer has, the greater the possibilities of crop rotation. Moreover, under such conditions he can farm with less risk than if he cultivated only a few crops and can make better use of his workmen, animals, machines, etc. So I

think it is worth while to mention two crops practically new to the United States, the chick-pea or garbanzo (*Cicer arietinum*) and the sesame (*Sesamum orientale*).

THE CHICK-PEA AND THE SESAME.

Chick-pea.—The chick-pea (fig. 9) is one of the most valuable legumes grown in Palestine. It does not demand such careful prep-

FIG. 9.—Branch of plant of chick-pea (*Cicer arietinum*), showing pods and white flowers. The variety with rose-colored flowers has black seeds, which are not so well liked as those of the white-flowered variety.

aration of the soil as sesame, and in good years it yields 12 bushels to the acre. It sells for as much as wheat, and often for more. It is therefore a remunerative crop and is excellently adapted for use as a rotation crop before wheat.

There are several sorts of chick-peas to be considered. Those of southern Palestine are different from those of central Palestine, and the plateaus of upper Galilee and farther north produce still different types. In the southern part of the country the chick-pea does well with a rainfall of 16 inches or even less. I know from personal experience that these races do not grow well under irrigation. On the other hand, in the north there are races growing at 4,000 to 5,000 feet altitude, where the yearly rainfall is as much as 40 inches, which are nevertheless liberally irrigated with water derived from the melting snows of Mount Hermon.

As there are in Palestine no bean harvesters like those used in the United States, chick-peas are gathered by hand, the plants being pulled up by Arab women. The stems of this plant growing in southern Palestine are very corrosive and attack the hands of the workers. I have thought that it would be a good idea to introduce cultivated varieties from the Crimea and the Caucasus. These have erect stems, so that they can be harvested with mowers; they have scarcely any corrosive quality and could be harvested by hand, but can not resist drought. The leaves and stems of the Palestine chick-pea are corrosive because they are covered with crystals of oxalates and other hygroscopic salts which probably absorb to some extent the moisture in the air; so, no matter how dry the night may be, a field of chick-peas always glistens with drops of water in the morning. Is it this condensation of atmospheric humidity which enables the plant to resist drought, while the Russian plant, not provided with this means for obtaining moisture, does not grow at all or gives a poor yield?

The importance of choosing a race may be illustrated by another example. Some years ago a little Jewish colony was founded south of Tiberias about 650 to 800 feet below sea level. The soil was a gypsum marl, the annual rainfall about $1\frac{1}{3}$ feet. The Arabs had cultivated only winter cereals, such as wheat and barley, asserting that no summer crop could grow there without irrigation. They cultivated chick-peas at Tiberias, but only in kitchen gardens. These latter were sown in winter in well-sheltered places, so as to profit by the winter rains. They came from Safed, scarcely 12 miles away, a locality with twice as much rainfall and 3,300 feet higher in altitude. I advised my brother, established in this colony, to try a variety of chick-pea not so well liked as that from Safed but coming from a place where the conditions were more like his own. The success of the first year surpassed all expectations. The neighboring colonists, seeing this, hastened to plant large areas with this chick-pea. I feared that they were planting on too large a scale and tried to prevent their doing so. But their experiment was so successful that the chick-pea is now one of the common crops of this colony, and

every year some hundreds of acres are sown in this locality where five to seven years previously its cultivation was considered impossible.

The chick-pea will, I think, do well in the dry-farming regions of the United States, and if its cultivation is properly developed it should become a more important crop than the Lima bean.

Sesame.—The sesames of Palestine are of most excellent quality. In the markets of Marseille and of Germany they pay a special price for the Haifa sesame. This is preferred to the sesame of Jaffa or the Ghor (the Arab name for the valley of the Jordan), for at Haifa, as we shall see, a local race has been developed under quite different conditions.

The soil must be well prepared for sesame. For the best results it should be pulverized until "as fine as ashes." Sesame is generally sown about the time of the barley harvest—that is, about the end of April or the beginning of May, after the rains have stopped—for the Arabs have noticed that sesame germinates very irregularly if rain follows immediately after the sowing. They explain that this is because the oil in wet seed becomes rancid and therefore prevents germination. Although they have observed the fact correctly they have assigned a wrong interpretation. The real reason is that as after a rain a crust forms over the pulverized soil, the feeble sesame plants are not strong enough to break through it, so that the stand is irregular and too sparse. The Arab, who knows nothing about harrowing, does not know how to break up this crust. By harrowing we were able to sow sesame earlier and thus to have the benefit of the last rains. However, although the Arab tries to sow his sesame only after the rains, it grows as it gets sufficient moisture from water stored up in the soil.

South of Jaffa, where the rainfall is not more than 14 to 16 inches, the sesame is grown upon sandy clayey soils. At Haifa the rainfall averages more than 24 inches and sesame is grown on rich ground of volcanic origin, so that a very different race and one of a much better quality is developed there. In the valley of the Jordan the situation is still different. There, after barley or wheat has been harvested and the ground copiously irrigated, the sesame is sown on well-prepared soil. It grows without any further irrigation, under a torrid sun and in an alkaline soil, but here the reserve of water stored up in the soil is greater than at Jaffa or Haifa. We see, then, that under different conditions local races adapted to such conditions are developed, and this indicates to us how much care and study is necessary when we introduce new plants into strange surroundings.

I do not believe that under present labor conditions sesame can be profitably cultivated in the United States, because the plants of the crop do not all mature at the same time. This makes necessary

several harvestings, always by hand. With the prices for labor now prevailing in the United States this would not pay. But, by means of methodical selection, uniformity in the germination and maturing of these plants could easily be obtained.

I believe, therefore, that the chick-pea and the sesame deserve to be introduced into the semiarid regions of the United States and that they will furnish valuable aid to the farmer in the rotation of crops.

CEREALS.

Barley.—After having discussed the number and value of the local races in other crops, little remains to be said regarding barley and wheat. There are, of course, in Palestine a great number of varieties of these grains. There are barleys belonging to the three botanical species *Hordeum distichon*, two-rowed barley; *Hordeum vulgare*, ordinary six-rowed square-headed barley; and *Hordeum hexastichon*, the true six-rowed or club barley.

The species most extensively cultivated is *Hordeum vulgare pallidum*. Gaza barley belongs to this variety. It is cultivated in southern Palestine on lands of Cenomanian or of Pleistocene origin and where the annual rainfall is often not more than 10 or 12 inches. It is much used for brewing in England. More than a million dollars' worth is exported annually.

The barley of the Ghor or that of the Jordan is heavier and has the more regular grains characteristic of *Hordeum hexastichon*, the true six-rowed barley. It is a barley adapted to arid regions and to alkaline soils. The barleys cultivated on the vast steppes around Damascus belong principally to *Hordeum distichon*, or two-rowed barley.

Wheat.—Though the greater number of the cultivated wheats of Palestine belong to the group *Triticum durum*, this is not the only group represented. Some belonging to *T. aestivum* and to *T. turgidum* are cultivated, especially in the northern part of the country. There are a great number of kinds of *Triticum durum*. At the little market of Haifa there are five or six different races. I shall mention only the "Nursy," the "Zeriin," and the "Dalaika," named after the villages which produce them.

The first has a long and rather thin grain and is splendidly adapted to low, humid, almost marshy soils. The wheat of Zeriin has a large, full, white grain and is adapted to the hills of the Senonian limestone formation. The wheat of Dalaika has a small, translucent grain. It is a favorite in the markets and grows on soil of volcanic origin, which is very fertile but subjected to such intense sunlight that no other variety can stand it.

Now, the three localities mentioned are hardly 10 miles from one another, yet each one has its special race. What is the significance

of this fact? From the physical and geological nature of Palestine, as has been explained in the introduction, there necessarily resulted a diversity of climates within a very small area, and this diversity of both soil and climate has given rise to a very rich and varied flora and fauna. In the cultivated plants a multiplicity of forms has also been favored by the political as well as by the natural conditions. The country has for centuries been divided among a number of hostile tribes, each one living in a territory of quite definite natural boundaries. The hostility of these neighboring tribes was so great that nearly all commercial relations were destroyed, the only interactions being those of warfare. Access to the markets was thereby cut off, and the Arab learned to depend entirely upon the products of his own immediate district. As the same products continued to be cultivated for centuries on the same soils without outside introduction, local races were necessarily developed. These conditions, which lasted for more than ten centuries in the Orient, are finally rapidly disappearing.

From a human point of view we have every reason to rejoice at the pacification of the Orient, because of the greater safety to life and property and the better intercourse it has brought about; but from the standpoint of the cultivation of plants we are losing ground, for it is a natural tendency to reject all of the old habits and in so doing to annihilate many of these local races which have been in process of development for so many centuries. This can best be illustrated by the following example:

When the Jewish colony of Yemma was established at Dalaika, the colonists, who had no feeling of prejudice or hostility toward the Arabs of Nursy and Zeriin, thought it would be an improvement to give up the small-grained Dalaika wheat and to introduce the fine, large-grained wheat from Zeriin. The result, of course, was a failure, because the wheat introduced was not adapted to local climatic conditions. Instead, however, of correctly interpreting their failure, some of the colonists attributed it to the use of European plows, and others to American harrows, both of which had been recently imported. (See fig. 10.) I enter into these details in order to show the value of the local products which the Orient has developed during the centuries of stagnation, and also to point out the danger of the destruction of these races of plants in consequence of the general leveling which is a necessary accompaniment of national awakening and progress. An early botanical-agronomic exploration of the Orient is therefore necessary. The sooner it is made the greater will be the chances for obtaining valuable races of plants.[a]

[a] The importance of this point has been emphasized by A. F. Woods. See Science, n. s., vol 26, no. 669, pp. 541–543; also Report of the National Conservation Commission, vol. 3, 1909, pp. 146–150.

MEDICINAL AND MISCELLANEOUS PLANTS.

In the preceding pages I have referred only to crops which can be extensively cultivated and promise to be of considerable economic importance. But there is a host of plants of secondary importance which ought also to be mentioned.

For example, in the Cucurbitaceæ we cultivate *Cucumis melo*, *Citrullus vulgaris* (watermelon), *Cucumis chate*, and *C. melo dudaim*.

Of the different races of watermelon cultivated in Palestine I shall mention only two. The "Abu-taba" (father of the ring), so called because of the large scar which it has in the place of the pistil, is cultivated chiefly along the coast in the neighborhood of the Jewish colony Hedera. It is exported to the value of $200,000 annually (see fig. 11), chiefly from Cæsarea and Minet Abu-Zabura. The

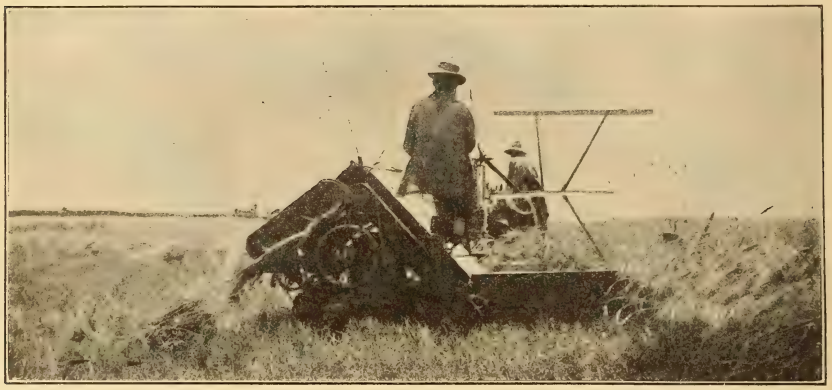

FIG. 10.—An up-to-date Jewish farmer in the dry-farming region of the Jordan Valley using an American-made binder.

latter is a temporary harbor maintained only during the shipping season of these melons. This Abu-taba, which grows on the poorest soil, is very early, and because of its thick rind it is uninjured by journeys of two to three weeks. It is therefore shipped to Egypt, Smyrna, and Constantinople.

Another rather curious sort is that cultivated in the neighborhood of Tiberias. It is not so early as the one just mentioned and does not have such good shipping qualities, but it is much liked on account of the sweetness of its fruit. It is very small, being only about the size of a grapefruit.

There is a kind of muskmelon, cultivated chiefly by the Bosnians in Cæsarea, that is kept until late in the winter. It is, I believe, derived from the sort cultivated at Kirk-Agatch, in Anatolia, a variety propagated in California under the name "Casaba."

I may also mention *Citrullus colocynthis*, a medicinal plant. The fruit grows wild and is gathered for export, chiefly to the United States. The region in which it grows best is a sandy desert between Gaza and El-Arish.

There are other wild plants useful as vegetables, etc.; for instance, *Gundelia tournefortii*, the "Akub" of the Arabs, which grows wild in rocky localities. Its white, juicy shoots are gathered by women and eaten like artichokes. Cargoes of this plant are shipped along the coast from the rocky regions around Haifa, particularly to Beirut. It is a very good vegetable and worthy of recommendation. Its leaves are somewhat spiny when fully developed, but by selection this slight defection could easily be overcome.

FIG. 11.—The watermelon market at Jaffa.

I may also mention the wild *Cynara syriaca* and *Cynara auranitica*, closely related to the cultivated artichoke. The former grows in the damp soils of the low plains along the coast; the latter in the deep, dry soils of the high plateaus of the Trans-Jordan. Their improvement and their use for crossing are to be recommended.

Among the plants particularly adapted to desert regions is *Tamarix articulata*, the "Athl" of the Arabs. Its galls are used for tannin. It grows well in sand dunes and has been successfully cultivated in southern Tunis. This tree is easily propagated by cuttings and appears to me to be well adapted to the southwestern United States.

Another desert plant, *Calligonum comosum*, resembles *Zizyphus lotus* in its habit of growth. It is even more useful than the latter for the fixation of sand dunes. It sends out roots 65 to 100 feet

long, just beneath the surface of the ground. These roots form large nodules, probably because of the sting of an insect, though this matter, so far as I know, has not been studied. These nodules are tolerably close together and like knots in cords, thus making the shrub very valuable in the fixation of dunes. A related species, *Calligonum caput-medusae*, has been used with remarkable results in the fixation of dunes from the Caspian Sea to Turkestan.

It is not my intention in this bulletin to give a complete list of the plants which it would be advantageous to import from Palestine. I wish simply to give a few examples to illustrate the interest that Palestine and the surrounding countries, Arabia, Syria, Mesopotamia, and Anatolia, should awaken in the United States. These countries have been centers of cultivation for many centuries and contain products of great importance to the progress of agriculture, both in their wild types and in the cultivated forms in which they have been grown from time immemorial.

WILD PROTOTYPES OF WHEAT AND OTHER CEREALS IN PALESTINE.

HISTORICAL INTEREST OF WILD WHEAT.

Thirty years ago De Candolle[a] said that the question of the origin of cultivated plants was of importance not only to agriculturists and botanists but to historians, philosophers, and all who are interested in the birth and development of civilization. The fathers of history, Herodotus, Homer, Diodorus of Sicily, and others who lived in the age when mythical deities ruled the minds of the people, always attributed to some god the task of having taught men the uses of plants. At one time and in one nation it was Isis and Osiris; at another, Ceres or Demeter of Triptolemus; but never a thought was given to man's own ingenuity or to his own need as the reason for cultivation. This shows that the cultivation of plants goes back to very ancient times, for when these legends were formulated all recollection of the real origin of cultivation had long since vanished.

As the races developed, the love of legend was replaced by the desire for truth, and in the beginning of the nineteenth century the study of natural science had advanced to such a stage that people demanded facts based upon scientific observation. So we find Link, in 1816,[b] and Dureau de la Malle,[c] in 1826, writing on "The Ancient

[a] De Candolle, A. Origin of Cultivated Plants.

[b] Link, H. F. Ueber die aeltere Geschichte der Getreidearten (Vorgelesen den 20 Marz, 1817), in Abhandlungen der Akadamie der Wissenschaften zu Berlin aus den Jahren 1816–1817, Berlin, 1819, and November 9, 1826, Berlin, 1829; and in "Die Urwelt und das Alterthum," erlautert durch die Naturkund, 2d ed., pt. 1, Berlin, 1834.

[c] De la Malle, Dureau. Annales des Sciences Naturelles, ser. 1, vol. 9, Paris, 1826, pp. 61–82.

History, Origin, and Fatherland of the Cereals, Particularly Wheat and Barley." These scholars seem to have been the first to realize that scientific study was necessary to the solution of the problem and that historic and linguistic data could not be accepted if at variance with the botanical and geographical knowledge of their own time.

These men did excellent work, having a definite understanding of the question and using exact scientific methods. But, as Dureau de la Malle himself said, they could only set forth the probable facts in the case. In order to have positive proof they would have had to present wild individuals of every species under discussion and to prove that they really were wild.

Now, this seemed to be impossible, at least in regard to wheat; for it and the other cereals "do not perpetuate themselves in a wild state when they escape from cultivation." The Count of Solms-Laubach ten years ago[a] declared that the genealogical record of wheat had disappeared forever and that its life history could be rewritten only by hypothesis. Although we knew congenerous wild species of barley, rye, and oats that might reasonably be considered as the prototypes of the cultivated species, we knew of no such wild species of wheat. It had been generally admitted that *Hordeum spontaneum* (*H. ithaburense*) was the wild form of *H. distichon*, or two-rowed barley, and that *H. vulgare*, the common six-rowed square-headed barley, and *H. hexastichon*, the true six-rowed barley, were derived from this species. *Secale montanum*, likewise, was considered the prototype of cultivated rye (*Secale cereale*) and *Avena fatua* or some other wild Avena the progenitor of cultivated oats. But no one knew anything about the original wild form of wheat.

At one time, about the middle of the nineteenth century, it was thought that this much sought for wild form had been found in the neighborhood of Montpellier, France. It was then that the so-called *Aegilops triticoides* was first found in a wild state. It was later produced artificially by crossing *Triticum ovatum* (*Aegilops ovata*) and *Triticum aestivum* (in this case Touzelle wheat). But the researches and memorable publications of Fabre, Godron, Jordan, and others proved that this was not the desired prototype, and the assumption that the cultivated wheats were derived from Aegilops has long ago been abandoned by botanists. It is therefore to be regretted that it has recently been reprinted by certain agronomists in their treatises on the cereals.

DISCOVERY OF WILD EMMER, AND KÖRNICKE'S THEORY REGARDING IT.

Although, as we have seen, almost all botanists agreed with Solms-Laubach when he declared that the prototype of wheat could never

[a] Weizen und Tulpe und deren Geschichte. 1899.

be discovered, there was a small group of the most distinguished botanists who maintained not only that such a prototype existed but that they already had it in their possession. In 1873 Körnicke, when preparing the notes for his standard work on the cereals,[a] had discovered in the herbarium of the National Museum of Vienna, among the stems of *Hordeum spontaneum* which Kotschy had gathered at Rasheyya, on the northwestern side of Mount Hermon, in 1855, part of an ear of a graminiferous plant which he considered to be a wild wheat and which resembled the emmer (*Triticum dicoccum*). But, with an unaccountable forgetfulness, Körnicke did not speak of this discovery in the work mentioned, which appeared in 1885, and it was not until 1889, at a meeting of the Society of the Lower Rhine and Westphalia, that he reported his discovery.[b] At that time he named Kotschy's plant *Triticum vulgare dicoccoides* and declared it to be the prototype of the cultivated wheats. Afterwards Körnicke returned repeatedly to the discussion of the question, urging all botanists who went into the region of Mount Hermon to give their attention to the subject and trying to induce the scientific academies of Vienna and Berlin to organize an expedition for that purpose. His efforts, however, were in vain.

In 1902 Ascherson and Graebner published their "Synopsis of the Middle European Flora." In this work, in the monograph dealing with the Tritici, they set forth Körnicke's views, which thus reached a large public. In order to understand why Körnicke believed that Kotschy's plant represented the wild prototype of wheat, it is necessary to know something of the conclusions he had reached regarding the classification and development of the genus Triticum, which includes wheat and several closely related grasses.

BOTANICAL CLASSIFICATION OF WHEATS.

In the work just mentioned, which adopts the excellent classification of Körnicke in its essential features, but also takes into account the investigations of Hackel, the wheats are classified as follows:

In the section Eutriticum there are three species—*Triticum monococcum* (einkorn), *Triticum polonicum* (Polish wheat), and, thirdly, a collective species, *Triticum sativum*.

Triticum sativum is divided into three small species:

Triticum dicoccum (emmer).
Triticum spelta (spelt).
Triticum tenax (common wheats).

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[a] Körnicke and Werner. Handbuch des Getreidebaues. 1885.

[b] Verhandlungen des Naturhistorischen Vereins der Preussischen Rheinlande, Westfalens, und des Regierungs-Bezirks Osnabrück. Bonn, 1889.

One of these, *Triticum tenax*, is in turn subdivided into subspecies:
Triticum vulgare (wheat). [*Triticum aestivum.*]
Triticum compactum (short-eared wheat, club wheat).
Triticum turgidum (Poulard wheat).
Triticum durum (durum wheat).

This classification is essentially artificial, and the distinctions between the groups are very difficult to maintain. Near the close of Körnicke's life, after having made a specialty of this study for forty years, he declared that it was almost impossible to distinguish between some forms of *Triticum durum* (subspecies of *T. tenax*) and *Triticum dicoccum* (small species of the collective species *sativum*).

The behavior of crosses and hybrids also indicates a very close relationship among the so-called species. Thus, Vilmorin crossed *Triticum aestivum* and *T. durum* and obtained a *T. spelta*. *Triticum polonicum* occupies a somewhat unique place on account of its long glumes, but it hybridizes with the other species and is regarded itself as only a hybrid. *Triticum monococcum* alone holds a place entirely distinct from all of the others because of its refusal to hybridize with the rest. In fact, all of the other species pass so gradually into one another that it seems more than probable that all of the wheats belong to one species.

THE BRITTLE RACHIS OF THE PRIMITIVE CEREALS.

What can we suppose the prototype of wheat to have been, and by what characters can it be recognized? A fragile rachis was undoubtedly one of the characters of this wild prototype. All who have studied the question agree as to this. All agronomists and all botanists regard a rigid rachis as an acquired characteristic, developed by man under cultivation and having a tendency to destroy the plant's natural capacity for dissemination.

All of the genera and species related to wheat, as Aegilops, Agropyron, etc., have this fragile rachis, a necessity in order that the grain be assured a wide dissemination. It is also needful that the grain remain fixed in its glumes as a general protection against premature germination, decay, and destruction by enemies. But this characteristic, so useful to the plant itself, was a drawback to its use by man. Wheat with a brittle rachis requires to be harvested before complete maturity and is difficult to handle. Moreover, grains that are held too closely in the glumes can not be thrashed with flails, but a special system of mills must be used. In Egyptian tombs 6,000 years old have been found heaps of emmer hulls, a careful inspection of which clearly indicates that they were thrashed by such mills, so that their use must date from the most ancient times.

Wild wheat, the same as wild oats and wild barley, must have been provided with the means for ready dissemination. Man, however,

naturally wishes to develop forms which are not so difficult for him to handle, and along this line he has succeeded in obtaining a rigid rachis in barley as well as in wheat. An important difference between the cultivated two-rowed barley (*Hordeum distichon*) and the wild barley (*Hordeum spontaneum*) is the fragile rachis of the latter. But more than this has been accomplished with wheat. Forms have been developed in which the grains are very readily removed from the glumes. In barley and oats this has not been done to the same extent. We have, it is true, naked varieties of these two cereals, but these varieties have not been extensively cultivated, doubtless on account of their relatively smaller yield, and until a comparatively recent date their cultivation has been confined to the Orient. In wheat, on the contrary, naked grains and a rigid rachis are the general rule, these two characteristics differentiating the cultivated forms from the primitive type and making the former incapable of perpetuating itself without the intervention of man.

CULTIVATED WHEATS WITH A BRITTLE RACHIS.

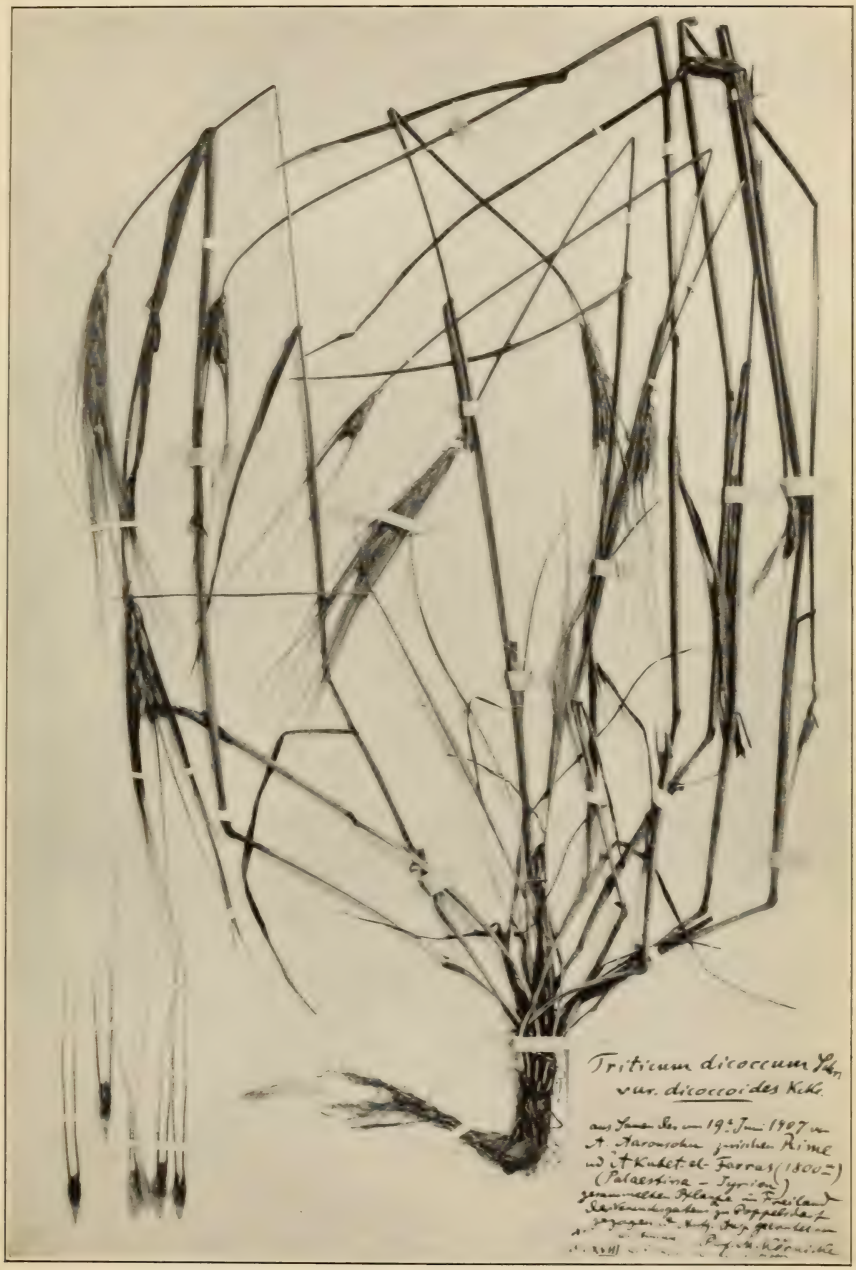
Among the known cultivated wheats there are three that still retain the brittle rachis: Einkorn (*Triticum monococcum*), emmer (*Triticum dicoccum*), and spelt (*Triticum spelta*).

It is known that the cultivation as grain crops of einkorn, emmer, and spelt is steadily decreasing. An attempt has been made in comparatively recent times both in this country and in Russia to cultivate einkorn and emmer as forage plants. It is interesting to note that, except for these attempts, these wheats are cultivated to-day only by the Basques, the primitive Swabians, the Serbes, and that peculiar people the Bactrians of Persia.

The cultivated wheats with a rigid rachis are therefore derived from the wheats with a brittle rachis. But of the three species which have this common character, which one shall we select as the prototype and why make this selection to the exclusion of the others?

EINKORN AND ITS PROTOTYPE DISTINCT FROM OTHER WHEATS.

More than fifty years ago Balansa discovered *Triticum monococcum aegilipoides* in the wild state. This differs from the cultivated *Triticum monococcum* only in minute characters and is without doubt its prototype. Balansa believed that he had found the progenitor of the cultivated wheats, an opinion that Haussknecht also accepted at the time. But experiments in crossing undertaken more than thirty years ago by Vilmorin led him to assert that whereas all the other species of wheats crossed with each other perfectly and gave mongrels, or fertile offspring, he had never succeeded in crossing



TRITICUM DICOCCUM DICOCCOIDES, ENTIRE PLANT.

(Reduced to one-third natural size.)

Triticum monococcum with any other wheat. Later, Beyerinck succeeded in producing the cross, but the products were strict hybrids; that is, they were all sterile. More recently still, Professor von Tschermak, who took up Vilmorin's experiments, met with the same failure. He has succeeded in crossing *Triticum monococcum* with *Triticum oratum*, which, as we have seen, may in turn be crossed with *Triticum aestivum;* but neither he nor anyone else has succeeded in crossing *Triticum monococcum* with any other wheat.

Let us note, however, that in the case of *Triticum polonicum* there was difficulty in crossing, because of the peculiar form of its glumes, until a particular operative technique had been worked out. In view of this we may question whether the failure with einkorn was not also caused by a faulty technique. We may remark in this connection that, as Doctor Trabut observed,[a] no one has ever succeeded in crossing the two varieties of *Anagallis arvensis*, *caerulea* and *phoenicia*, although the only difference between the two is that the former has blue and the latter pink flowers. But we can not on this account class them as distinct species.

In so far, therefore, as the lack of sexual affinity between two related forms justifies us in recognizing in them two different species, *Triticum monococcum* must be considered as standing alone, and it can not be ranked as the progenitor of the cultivated wheats.

From the historical point of view, also, we may reject einkorn as the progenitor of wheat. Its cultivation can not have gone back to very ancient times, since the cultivated form differs so little from the wild one. The only evidence that we possess of any antiquity is that Schliemann discovered it in his celebrated excavations of ancient Troy, showing that it was cultivated there. But the other cultivated wheats are traced back for thousands of years before this.

Spelt and emmer, then, are the only two forms remaining to be considered, but we have no ancient remains of the cultivation of spelt, nor is there any mention of it in literature until toward the beginning of the Christian era.

EMMER THE ONLY POSSIBLE PROTOTYPE OF TRUE WHEAT.

The species of grain of the cultivation of which we have the oldest records is emmer. It is true that durum wheat has been found in Egypt in some tombs of the first dynasty—that is, four thousand years before the Christian era—but emmer is found both in far greater abundance and in all of the tombs. It is not at the present time cultivated anywhere in Egypt, durum wheat having since historical times taken its place.

[a] Bulletin de la Société Botanique de France, vol. 68, p. 182.

Emmer has been found in the lake dwellings of Wangen and Robenhausen, which date back to the end of the neolithic epoch, a little before the bronze age. This, therefore, is the only species which has been cultivated from the very beginning of civilization, and we are justified in asserting it to be the progenitor of our cultivated wheats. This explains why it was so desirable to find the wild form.

REDISCOVERY OF WILD EMMER IN PALESTINE AND SYRIA.

This was the state of the question when, in the autumn of 1902, I was in Berlin. Professors Ascherson, Schweinfurth, and Warburg at that time called my attention to the importance, from a theoretical point of view, of finding this wild form of emmer. Then only the theoretical phase of the question was under consideration. As I was then living in Palestine, not far from Mount Hermon, I decided to undertake an investigation of this subject. My ambition was simply to rediscover Kotschy's plant, which had definitely taken the name of *Triticum dicoccum dicoccoides*. This name was necessarily given to it in order to conform to the rules of nomenclature; and thus we have, strangely enough, the wild type taking the name of a variety while the cultivated type bears the name of a species. I had the good fortune to rediscover this plant, and I have studied it since 1906.

In June, 1904, as I was in upper Galilee preparing a geognostic map of the region, I went as far as the foot of Mount Hermon looking for *Triticum dicoccum dicoccoides*, but failed to discover it. I was not very persistent in my search because I had very little hope of success. I knew that both the late G. Post, the author of "Flora of Syria, Palestine, and Sinai," and Joseph Bornmüller, author of "Beiträge zur Kenntniss der Flora von Syrien und Palästina," had spent a great deal of time botanizing in the neighborhood of Rasheyya, the locality on Mount Hermon from which Kotschy's specimen was supposed to have come. As these skillful botanists did not report any Triticum, I concluded that Kotschy's specimen must in reality have come from some other place—that an error had been made in attributing it to Rasheyya. But when I visited Berlin in the summer of 1905 Messrs. Ascherson and Schweinfurth brought up the question again, and I decided to resume the investigation at the earliest opportunity.

In June, 1906, I took a long trip to upper Galilee, intending to go as far as Mount Hermon and to spend as much time as necessary in looking for *Triticum dicoccum dicoccoides*.

On June 18, I was walking with my friend, the agronomist Mr. M. Bermann, in the vineyard of the Jewish Agricultural Colony at Rosh Pinar, at the foot of Jebel Safed (see Pl. I, fig. 2), and was trying

LOWER FACE OF SINGLE SPIKELET OF TRITICUM DICOCCUM DICOCCOIDES.

(Enlarged about 5 diameters.)

UPPER FACE OF SINGLE SPIKELET OF TRITICUM DICOCCUM DICOCCOIDES.

(Enlarged about 5 diameters.)

to demonstrate to him the Eocene origin of the ground. Suddenly I noticed in a crevice of a rock of nummulitic limestone an isolated plant which at first sight looked like a stool of barley, but which on closer inspection proved to be a wheat, the ripe spikelets of which could be detached from the brittle rachis by the slightest shake. I could hardly believe that it was really the plant for which I was looking. The development of the head and grains was so perfect—so nearly like the forms produced under cultivation at the present day—that I could scarcely believe that this was their wild prototype, though, to be sure, if it had not been so well developed primitive man would not have noticed it, or at least would not have appreciated the importance of its cultivation to such an extent as he did.

I could not at that time remain longer at Rosh Pinar, and so left the next day for the north. On the way from Rosh Pinar to Rasheyya (three days on horseback) I looked for wild wheat, but could not find any. At Rasheyya, too, I spent a great deal of time botanizing in the vineyards in the hope of finding the Triticum there, but also without success. But when I began to extend my search to uncultivated lands, along the edges of roads and in the crevices of rocks, I found a few stools of the wild Triticum. Later I came across it in great abundance, and the most astonishing thing about it was the large number of forms it displayed. The sample specimen from Rosh Pinar, however, was the finest one. This plant had made a very vigorous growth and bore heads the stiff, rugose awns (beards) of which were nearly or quite 6 inches long. (See Pls. II, III, and IV.) At the foot of Mount Hermon the stems were longer but fewer. Instead of being 2 feet high, as at Rosh Pinar, this wild wheat at Rasheyya was more than 40 inches high.

I ascended Mount Hermon and went around to the other side. I intend at some future time to describe this trip, as its botanical and geological results may interest the scientific world; but here I shall speak only of the Triticum. In descending from the summit of Mount Hermon (9,498 feet in altitude) toward Arny, a little village on its eastern slope, I found innumerable forms of this wild Triticum growing in abundance at an altitude of 5,250 feet and less. (See Pl. V, fig. 1.) In some cases the whole ear was black; in others only the glumes or part of the glumes; in still others the awns alone were black. Sometimes the glumes were completely glabrous (see Pl. VI, figs. 1 and 2), sometimes very hirsute (see Pl. VII, fig. 1); in some the form of the glume resembled that of *Triticum durum* (see Pl. VI, fig. 2), in others the development of the secondary nerve was similar to that of *T. monococcum*. (Compare Pl. VIII, figs. 1, 2, and 3.) I had discovered so many forms that no attempt at determination could be made. Among these was even *T. monococcum aegilipoides* (see Pl. VII, fig. 2), a form I had not at all expected to

find. I could therefore only gather specimens, noting their habitat, associations, etc.

As soon as I got home I wrote the good news to my friends in Berlin. A short notice of the results of this trip and an article by Professor Schweinfurth on the importance of this discovery and on the possibilities which it opened up were published.[a]

My trip of 1906 merely established the native habitat of *Triticum dicoccum dicoccoides*. It was still necessary to find out the extent of the distribution, its habit of growth, etc., and I made another trip for this purpose in 1907. The principal results of this trip relating to problems of the cereals in their wild state have been published, with an introduction by Professor Schweinfurth[b] and an appendix by Professor Ascherson, in the proceedings of the Botanical Society of Berlin.

On this trip I was able to show conclusively that *Triticum dicoccum dicoccoides* is indigenous to the regions of Mount Hermon and the northern part of the Trans-Jordan. The idea that it is a plant escaped from cultivation can not be entertained for a moment. In the first place, *Triticum dicoccum* is not cultivated anywhere in Syria and Palestine. I have not been able to discover any hybrid or mongrel between this wild wheat and the cultivated forms. Second—and this is the important point—our *Triticum dicoccum dicoccoides* rarely appears on soils which have been cultivated for any purpose. It grows only upon the slopes of the most arid and rocky hills and in places exposed to the hottest rays of the oriental sun.

DIVERSITIES OF WILD EMMER.

The number of forms of *Triticum dicoccum dicoccoides* which I gathered in 1907 is astounding—" verblüffend," to use Körnicke's own expression. I found specimens in which the glume had a secondary tooth (compare Pl. VIII, figs. 2 and 3), produced by the great development of the secondary nerve, which constitutes a morphological resemblance to *Triticum monococcum*. And, on the other hand, I found forms of *T. monococcum aegilipoides* with the secondary tooth less developed than any that Körnicke had ever seen. We may presume that these were transitional forms.

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[a] See Aaronsohn, A., and Schweinfurth, G., Die Auffindung des wilden Emmers (Triticum dicoccum) in Nordpalästina, in Altneuland Monatsschrift für die wirtschaftliche Erschliessung Palästinas, Berlin, July–August, 1906, nos. 7–8, pp. 213–220; also Prof. Dr. G. Schweinfurth in Vossische Zeitung, September 21, 1906, and in Annales du Service des Antiquités de l'Égypte, 1906.

[b] Schweinfurth, G., Ueber die von A. Aaronsohn ausgeführten Nachforschungen nach dem wilden Emmer (Triticum dicoccoides Kcke.). In Berichte der Deutschen Botanischen Gesellschaft, 1908, vol. 26 a, pt. 4, 1908, pp. 309–324.

FIG. 1.—VIEW OF MEJDEL ESH SCHEMS, ON THE SLOPES OF MOUNT HERMON, WHERE WILD WHEAT WAS FOUND.

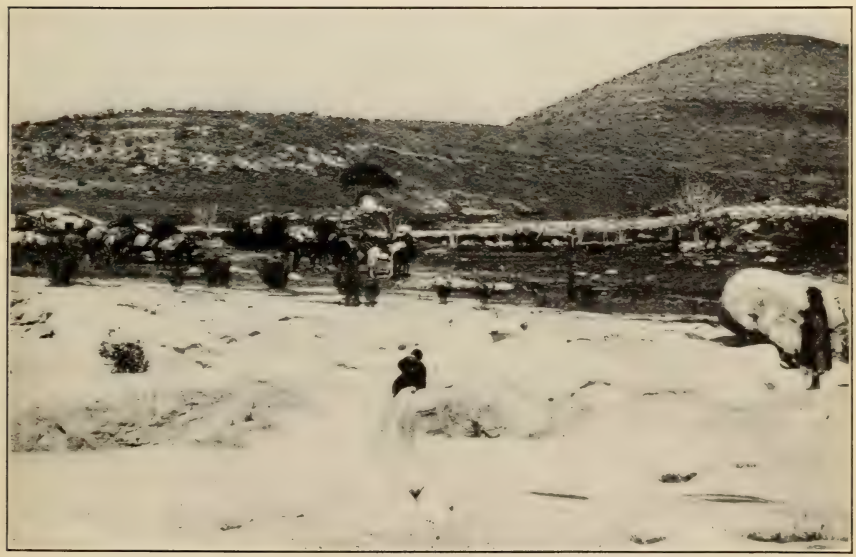

FIG. 2.—SCENE IN WADY WALEH, SHOWING THE WRITER'S CARAVAN. WILD WHEAT AND BARLEY GROW ON THE ROCKY HILLS.

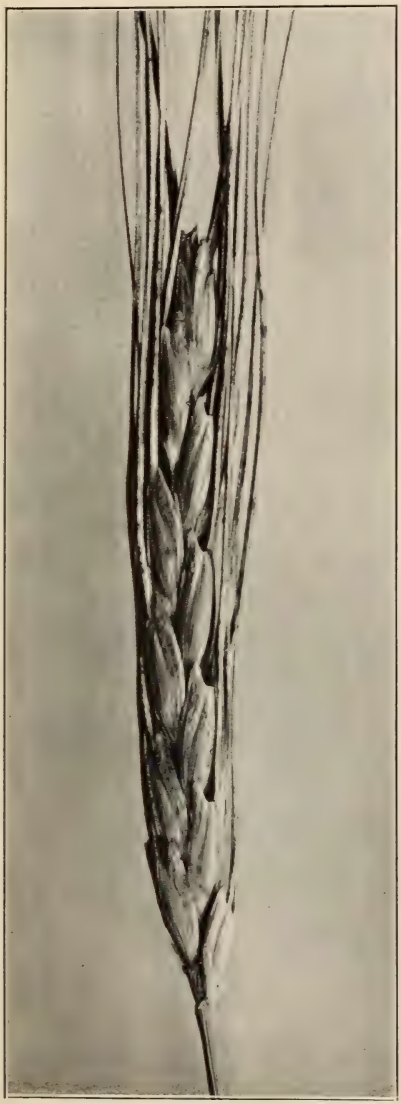

FIG. 1.—SPIKE OF TRITICUM DICOCCUM DICOCCOIDES, SHOWING LONG GLUMES; A TRANSITIONAL FORM TO T. POLONICUM.

(Natural size.)

FIG. 2.—SPIKE OF TRITICUM DICOCCUM DICOCCOIDES, SHOWING GLUMES RESEMBLING THOSE OF DURUM WHEAT.

(Natural size.)

I discussed this subject with Körnicke. A year before he had said that certain forms which I had labeled *T. monococcum* were really *T. dicoccum dicoccoides*, and vice versa. But after a minute study of these forms he took pleasure in acknowledging that my determinations were correct, stating this both in his letter to Professor Schweinfurth, dated December 31, 1907, and in his letter to me written a few days before his death.

HABITUAL ASSOCIATION OF WILD EMMER WITH WILD BARLEY.

Another observation of some importance made by the writer is the following:

The wild emmer is always found in company with wild barley. The latter has perhaps a greater area than the former and occasionally is found where wild emmer does not grow, but it is very unusual to find the emmer unmixed with the barley.

Now, it has always been difficult to say whether barley or wheat is the older crop. The oldest writers always speak of these two together, and in excavations in Egypt and elsewhere they are always found associated. Körnicke has asserted that the cultivation of barley is older than that of wheat. But why may we not assume that our prehistoric ancestors began the cultivation of the two cereals simultaneously and that they grew barley and wheat together just as they are found growing when wild? The habits of these two plants are so similar that the Arabs fail to distinguish them, although they are given to more or less close observation of natural phenomena. Several times I have asked the Arabs to gather for me some stools of wild Triticum like the sample which I gave them. They always brought me back *Hordeum spontaneum*. Nor have I been able to find any special word in their language for wild wheat. They always called it "scha'ir barri" or "scha'ir iblisse" (wild barley or devil's barley). But when I asked if it was not wild wheat, they admitted that it was "kamh barri" (wild wheat), being eager, as the Arab always is, to agree with the opinion of a guest.

DISCOVERY OF RYE, BOTH WILD AND CULTIVATED, IN SYRIA.

On my 1907 trip I was able to demonstrate that *Triticum dicoccum dicoccoides* and *Triticum monococcum aegilipoides* are indigenous to the vicinity of Mount Hermon; to study their distribution, their preferences as to location, and their habits of growth; and to gather a number of intermediate forms, and to study their association with each other and with *Hordeum spontaneum*. But, in addition to this, I made another discovery which I should like to mention.

I found some stools of cultivated rye (*Secale cereale*) at Damascus in a field of wheat. Now, two days later at Zebedani, on the Anti-

Lebanon, I gathered a stool of *Secale montanum*. It is an interesting fact, too, that the wheat in which the cultivated rye was found was *Triticum durum melanopus* (*T. complanatum*), having a starchy and not a glassy grain.

Now, it has been asserted as a fact that in ancient times as well as in our own day rye has been unknown to the Orient. Philologists were ignorant of the special name for this cereal in the Orient, and they therefore concluded that rye must have originated in Europe. It was on this theory that Hoops, Much, and others based their conviction that the cultivation of the cereals originated in Europe. No one who knows how strongly Damascus has resisted European influence, even up to the present time, can for a moment believe that the rye which I found in the wheat field had been imported. It is to be noted, too, that the region to the east and the north of Damascus is almost unexplored, and it may therefore be that without our knowledge rye is more or less cultivated there. I have not yet found out the special name the Arabs use to designate this cereal.

WIDE RANGE OF WILD EMMER.

In 1908 I was commissioned by the Turkish Government to make a scientific exploration around the Dead Sea, and was thus enabled to extend my study of *Triticum dicoccum dicoccoides*.

While descending Engedi, on the western shore of the Dead Sea, in March, 1908, I noticed a plant of *Hordeum spontaneum* with unripe heads, but gave it no particular attention. On March 26, having gone around the Dead Sea to the south and having pushed tolerably far into Arabia, our caravan reascended from El-Mazra-a on the southeast shore of the Dead Sea, 1,300 feet below sea level, toward the plateau of Moab, which is in some places more than 3,300 feet above sea level. At 350 to 500 feet above the Dead Sea, where the salty marls began to give place to calcareous strata, we saw *Hordeum spontaneum* more and more frequently. The abundance of this and the conditions of soil and vegetation made me think at once of the wild emmer. But, though I looked carefully, I could not find it either that day or on the three following days, although wild barley was as plentiful as before. I attributed this to the season, for the barley had barely headed and the wild emmer, if there, would have been concealed. On March 28 we camped in the Wady Waleh (see Pl. V, fig. 2), with which we were familiar from a preceding exploration around the Dead Sea and where, on February 29, 1904, Professor Blanckenhorn and I had discovered flint implements from a paleolithic, or perhaps even an eolithic, epoch at the foot of the rude stone columns called "menhirs," some of which were overturned and some still standing (see fig. 12).

FIG. 1.—SPIKE OF TRITICUM DICOCCUM DICOCCOIDES, SHOWING LONG GLUMES; VERY HIRSUTE.

(Natural size.)

FIG. 2.—SPIKE OF TRITICUM MONOCOCCUM.

(Natural size.)

FIG. 1.—SPIKELET OF TRITICUM MONOCOCCUM, SHOWING THE CHARACTERISTIC SECONDARY TOOTH OF THE GLUME. FIG. 2.—SPIKELET OF TRITICUM DICOCCUM DICOCCOIDES, SHOWING THE SECONDARY TOOTH, AS IN T. MONOCOCCUM. FIG. 3.—SPIKELET OF TRITICUM DICOCCUM DICOCCOIDES, SHOWING THE ABSENCE OF THE SECONDARY TOOTH OF THE GLUME.

(All enlarged 4 diameters.)

At this latter visit the hills which bordered the Wady Waleh were so abundantly covered with wild barley that they and the valleys looked like fields of cereals sown irregularly and infested with weeds. I tried to picture in my mind the life of our prehistoric ancestors who lived on the banks of this delightful wadi (canyon). I believe, as does Eduard Hahn, that our ancestors were not exclusively hunters and shepherds, as they are generally supposed to have been. They were without doubt chiefly vegetarians, and in this region, where the growing season is very short, they must have learned at a very early date to gather and preserve grain. Their life here must have been a comparatively enviable one. The negroes of Africa are compelled to make bread from a species of Pennisetum and from certain

FIG. 12.—Monolith in Wady Waleh. At its foot paleolithic or eolithic flint implements were found. Wild wheat and barley were found on the hills in the background.

Poas, which are very hard to harvest; the peoples of the Sahara with great labor secure a coarse bread from the seeds of *Panicum turgidum* and of *Aristida pungens*, which latter is even in our day an article of commerce; the Touaregs live on the seeds of different Diplotaxis, *Eruca sativa*, *Senebiera lepidoides*, and other crucifiers; the Tibbus, of Siwah, live on bread made from the seeds of colocynth.[a] When we think of what these and other peoples of our own day have to use for food, we must acknowledge that the prehistoric inhabitants of the valleys and plateaus of the Trans-Jordan were to be envied when they had *Hordeum spontaneum* and, as we anticipated, *Triticum dicoccum dicoccoides* also in abundance. (See Pl. IX, figs. 1 and 2.)

[a] See Duveyrier, Les Touaregs du Nord, p. 204; P. Soleillet, L'Afrique Occidentals, p. 177; and Nachtigal, Sahara und Sudan, vol. 1, p. 249.

Everything here seemed to be favorable to the growth of the wild emmer. So, when I returned to Jerusalem in April, I communicated to Professor Schweinfurth my hypothesis that *Triticum dicoccum dicoccoides* grew in the country of Moab, as he continued to take an interest in my travels and has called my attention to a number of problems which otherwise would have escaped me. I resolved to return to the country of Moab at a more favorable time, in May, for example. My joy was unbounded when, on returning to the country of Moab and Gilead two weeks later, April 17, 1908, I found *Triticum dicoccum dicoccoides* while going from Tell Nimrin, in the valley of the Jordan, to Ain Hummar, on the plateau of Es-Salt. A little later it was found as plentifully as it had been in the neighborhood of Mount Hermon.

SOILS AND LOCATIONS PREFERRED BY WILD EMMER.

I may summarize my observations on *Triticum dicoccum dicoccoides* as follows: It is always found in the same sort of habitat—in the crevices of rocks, in places where the rocks are covered with only a thin layer of soil, in the most arid situations and those most exposed to the sun (see Pl. I, fig. 2, and Pl. V, figs. 1 and 2), and always associated with *Hordeum spontaneum*. In locations where the vegetation is abundant and the soil fertile and where the layer of "terra rossa" has increased in depth by the disintegration of the rock, *Triticum dicoccum dicoccoides* is not found, except in the shelter of clumps of bushes and small trees, such as *Poterium spinosum*, *Cistus villosus*, *Zizyphus spina-christi*, *Echinops viscosus*, *Centaurea* sp., etc. This was observed to be the case at Mount Hermon (see Pl. V, fig. 1), at Rosh Pinar (see Pl. I, fig. 2), and in the country of Gilead (see Pl. V, fig. 2).

As to the geological age of the rocks, I have found *Triticum dicoccum dicoccoides* on the Jurassic limestones and dolomites, on the so-called sandstones of Nubia, on the more or less dolomitic limestones of the Cenomanian and Turonian, and on the lower Eocene limestones, as well as on the basalts and basaltites. The only formations on which it does not thrive seem to be the Senonian rocks (made up chiefly of chalky and soft limestones or of flints) and the Nari, a conglomerate generally formed of elements of Senonian origin and similar to the "caliche" of the southwestern United States. This was observed at Gilead, as well as in the neighborhood of Rosh Pinar. In this latter locality I made sure that *Triticum dicoccum dicoccoides* was not to be found on the Senonian formations, which are there very extensive and varied, being represented by chalky marls, bituminous limestones, and limestones of *Schloenbachia olivetti*.

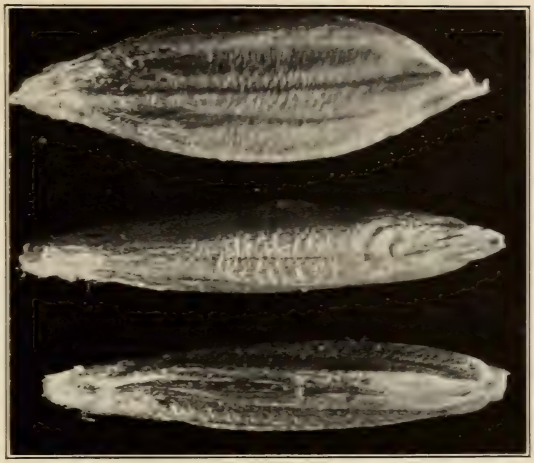

FIG. 1.—GRAINS OF TRITICUM MONOCOCCUM; SIDE, DORSAL, AND VENTRAL VIEWS.

(Enlarged 8 diameters.)

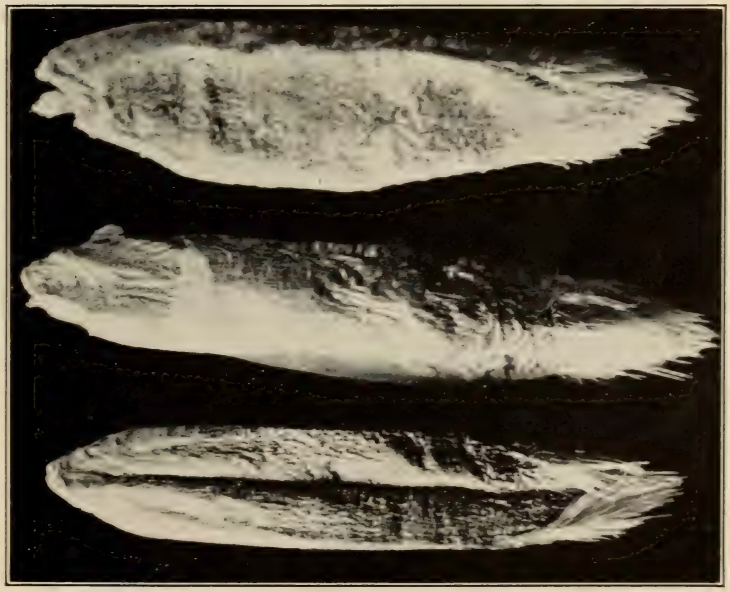

FIG. 2.—GRAINS OF TRITICUM DICOCCUM DICOCCOIDES; SIDE, DORSAL, AND VENTRAL VIEWS. NOTICE THE HAIRY APEX.

(Enlarged 8 diameters.)

We have seen that the wild emmer prefers rocky soils and has not been found up to the present time on the broad plains and vast steppes. Thus, I could not find it at the Ghor (the depression of the valley of the Jordan) either in 1907, when I searched for it in the neighborhood of the Lake of Tiberias, or in 1908 at the mouth of the Jabbok. It disappeared also on the road from Rasheyya to Katana when we reached the Senonian formations and the steppe toward the east. It does not seem even to extend to the edges of the rocky ground, but leaves a sort of protecting belt of rocky land between it and the alluvial, diluvial, or oolithic soils which border it.

Further search ought to be made to find out how far *Triticum dicoccum dicoccoides* extends toward the southeast of the country of Moab and toward Arabia, as well as how far north along the Lebanon and the Anti-Lebanon. Moreover, we should look further in the Cis-Jordan region, where it probably extends farther than the territory lying between Rosh Pinar and the northern part of Lake Tiberias.

WHERE DID THE CULTIVATION OF CEREALS ORIGINATE?

I believe that a careful consideration of the foregoing facts will throw some light on the question of the origin of the cultivation of cereals. I shall consider only three of the numerous hypotheses formulated in regard to this problem: First, there is the ingenious theory of the Count of Solms-Laubach, set forth in his work "Weizen und Tulpe," etc., previously cited.

He admits the polyphyletic origin of *Triticum aestivum*, but, having definite proof that wheat was cultivated in Egypt at least four thousand years before the Christian era and at least three thousand years before the same era in China and assuming that the Egyptian and Chinese civilizations were entirely independent and without influence upon one another, he reaches the conclusion that the cultivation of *Triticum monococcum* and of the prototype of *Triticum aestivum* must have begun in an age so remote that the division of land and sea, the climatic conditions, and the resultant flora were very different from those of the present day. It must, then, have taken place in central Asia, in the neighborhood of the basin of the Tarim, and at a time when the Desert of Gobi was still covered by the sea of Han-hai. Later, *Triticum monococcum* must have emigrated westward, while the prototypes of *Triticum aestivum* disappeared and only their cultivated descendants reached the west. But according to recent research it is not so certain that the Egyptian civilizations were entirely independent, and we hesitate to accept a theory which is doubtful in its conclusions, even though based on irrefutable geological premises.

Körnicke, as well as Schweinfurth and Ascherson, has always thought that the cultivation of wheat originated in western Asia in the region of the Euphrates. A. de Candolle also reached the same conclusion nearly thirty years ago as a result of his study upon the origin of cultivated plants. We take pleasure in quoting him: "The Euphrates Valley lying nearly in the middle of the belt of cultivation which formerly extended from China to the Canaries, it is extremely probable that this valley was the principal habitation of the species in very early prehistoric times. The area may have extended toward Syria, as the climate is very similar, but to the east and west of western Asia wheat has probably never existed but as a cultivated plant, anterior, it is true, to all known civilization."

The most recent theory—that claiming that the cultivation of cereals originated in Europe—has been discussed elsewhere,[a] and it hardly seems worth while to bring it up again. No naturalist will agree with Much, Hoops, and the other supporters of this hypothesis.

SUMMARY OF STUDIES OF THE WILD CEREALS.

I may say as a summary of the result of my investigations—

(1) I have fully confirmed the opinion of Körnicke, who was the first to assert that the specimen collected by Kotschy was a wild emmer, named by him *Triticum vulgare* [*dicoccum*] *dicoccoides*. This Triticum is a native of southern Syria and is the prototype of our cultivated wheats, or at least one of the oldest forms derived from such a prototype.

(2) I have shown that *Triticum monococcum aegilipoides*, as well as *Secale montanum*, is indigenous to the region of Mount Hermon and that rye (*Secale cereale*) occurs in the Orient, where it was thought to be entirely unknown.

(3) I have found forms morphologically intermediate between *Triticum dicoccum dicoccoides* and *T. monococcum aegilipoides*. Experiments in crossing, which are to be made later, will show whether these forms are only morphologically intermediate or whether they have closer sexual affinities than those which exist between the cultivated forms of *Triticum dicoccum* and *T. monococcum*.

(4) I have collected certain forms of *Triticum dicoccum dicoccoides* in which the development of the glumes and the whole appearance of the head recall *Triticum polonicum*.

(5) We have seen that *Hordeum spontaneum* is a satellite, so to speak, of *Triticum dicoccum dicoccoides*, and that the cultivation of the two species may have been begun at the same time.

[a] Aaronsohn, A. Contribution à l'Histoire des Céréales. Bulletin de la Société Botanique de France, March–April, 1909.

(6) I believe that the existence of all of these prototypes—that is to say, of oats, wheat, barley, and rye—in a single region, Syria and Palestine, tends to show that the cultivation of cereals must have originated there, or at least in closely adjoining localities.

ECONOMIC POSSIBILITIES OF WILD EMMER.

Hitherto we have devoted our attention to the theoretical and purely scientific phase of this question, but I have thought from the first that it may have a practical and economic interest. The fact that *Triticum dicoccum dicoccoides* endures the most extreme climatic conditions seems to me to be very important when we consider the future economic possibilities of the plant. Its distribution extends vertically for more than 6,500 feet. I have found it from 325 to 500 feet below the Mediterranean in the vicinity of the Jabbok (eastern tributary of the Jordan) and up to 6,000 to 6,300 feet above sea level at Mount Hermon, in the zone of alpine plants.

By the selection and crossing of this wild cereal, which prefers poor, rocky, shallow, dry soil and thrives without any cultivation, we should be able to produce new races which will be very persistent and very hardy. In this way we can extend the cultivation of wheat to regions where it is at present impossible on account of the low quality of the soil and the severity of the climate.

The writer has had the pleasure of seeing that many eminent scientists and practical men share this opinion. Körnicke's son and Mr. M. A. Carleton, the Cerealist of the Bureau of Plant Industry, are working on this problem. In the Vossische Zeitung for September 3, 1908, Professor Schweinfurth gives an account of the experiments carried on by the late Professor Körnicke, which will be continued by his son and successor in the chair of botany in the Agronomic Institute of Bonn-Poppelsdorff.

Of the thirty-six plats sown the first year of Körnicke's experiments more than thirty produced splendidly developed heads. Professor Schweinfurth shares my belief that this cereal shows very exceptional hardiness and adaptability, and he is certain that by selection and crossing we shall obtain some races especially adapted to arid regions and other races valuable for cold and elevated localities. Out of thirty-six plats sown last year, thirty-five came to fruition, and some of them produced heavier and more beautiful seeds than any of our cultivated wheats.

The countries adjoining the regions where *Triticum dicoccum dicoccoides* has been found should be carefully explored. We should determine its exact area of distribution and thoroughly study its numerous varieties and forms, their life history, pollination, etc. This would place us in a position to utilize these wild varieties to

the best advantage in the creation of new cultural races. It is impossible to foresee the importance of the results that may be thus obtained. Those who know what is being done at present in the way of creating interesting races by selection and with our present methods of hybridization will agree with me in saying that the cultivation of wheat may be revolutionized by the utilization of these wild forms.

It seems to me that we are justified in hoping to produce races better adapted to the semiarid regions of Algeria, Tunis, Syria, Egypt, Turkestan, and America. If we secure races that will enable us to increase the yield by as much as 1 bushel per acre on these vast areas, the world's total production of wheat will be very materially augmented.

The study of the wild types of our cereals should not serve merely botanical and historical ends. It has a practical, an economic—I may even say a social—importance. Its ultimate aim is to produce a little more bread at a little less expense where production is difficult and costly, and to render this production possible where up to the present time it has been impossible.

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